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LLAGAS GROUNDWATER BASIN NITRATE STUDY
NITRATE SOURCE AREA IDENTIFICATION

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LLAGAS GROUNDWATER BASIN NITRATE STUDY

Contract: 1-053-250-0

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I. EXECUTIVE SUMMARY

Communities in the southern portion of Santa Clara County rely solely on groundwater from Llagas Basin for their water supply. Over the years, groundwater from municipal and private water supply wells has been found to contain concentrations of nitrate greater than those allowed by federal safe drinking water standards. The Santa Clara Valley Water District (District), as well as other local agencies, is concerned with the elevated nitrate concentrations in Llagas Basin, and as a result, is conducting the Llagas Groundwater Basin Nitrate Study.

The present Maximum Contaminant Level (MCL) for nitrate in drinking water is 45 milligrams per liter (mg/l), as promulgated by the United States Environmental Protection Agency (USEPA). Higher concentrations of nitrate have been known to cause adverse health effects in infants.

Measures are being taken to ensure that drinking water standards for nitrate are being met. Affected municipal water supply wells are either no longer used or the groundwater from them is blended with groundwater from other wells containing lower concentrations of nitrate. Also, some of the private wells are using wellhead treatment systems to remove nitrates from the water.

The District is responsible for managing the groundwater basin to ensure its viability as a long term potable water supply. This study is exploring nitrate exposure prevention and source reduction alternatives and will recommend a specific nitrate management plan for the Llagas Groundwater Basin.

The study is being performed in the following phases: (1) review of historic nitrate data, (2) identification of categories of nitrate sources, (3) field sample collection, (4) evaluation of groundwater analytical results, and (5) development of a Nitrate Management Plan. During the first phase of work, the District evaluated historical nitrate concentrations in the groundwater of the study area. These evaluations are found in the study report "Nitrate Data Review" dated August 1993. During the second phase of this study, which this report summarizes, the District identifies sources of nitrate contamination in the study area. During subsequent phases of the study, the District will determine locations for sample collection, will collect new groundwater quality data, and will develop alternative strategies for reducing nitrate concentrations in order to continue providing a water supply that meets safe drinking water standards to the people of Llagas Basin.

A Technical Advisory Committee (TAC), including members of the community, has been assisting the District throughout the study, but is expected to provide the most input during the development of the Nitrate Management Plan.

LLAGAS BASIN GROUNDWATER FLOW

Llagas Basin has two hydrogeologic regions. One region is referred to as the forebay region, where rainfall and artificially recharged water percolates through the ground directly into the underlying aquifer. The forebay region is located in the northern part of Llagas Basin. The second region is known as the confined region and is located in the southern part of Llagas Basin.

In the confined region, a thick clay layer, known as an aquitard, separates the deeper water producing aquifers from shallow aquifers. Groundwater on top of this clay layer is primarily from rainfall, whereas groundwater flowing underneath the clay layer primarily originates in the forebay region. There is some vertical interconnection between these aquifers through old wells that may be screened in both shallow and deep aquifers. Other potential vertical connections between the aquifers include rootholes and geologic discontinuities.

The direction of groundwater flow in Llagas Basin is primarily south towards the Pajaro River. Due to the variable characteristics of the basin, the depth to ground water below ground surface differs throughout the basin but normally ranges from between 10 to 70 feet below ground surface.

FORMATION AND TRANSPORT OF NITRATES

Nitrate is produced when compounds which contain nitrogen (human and livestock waste, agricultural fertilizers, etc.) are introduced into the environment where they are transformed into nitrate in the soil via mineralization and nitrification. Mineralization is the process of organic nitrogen compounds being transformed into inorganic nitrogen compounds such as ammonium salts. Nitrification is the process of bacteria transforming those inorganic nitrogen compounds into nitrates. Except for certain chemical reactions that form minor amounts of nitrate from oxides of nitrogen in the atmosphere, this biological nitrification of nitrogenous compounds is the sole source of nitrate in the environment.

Once nitrogen containing compounds have been transformed into nitrate through mineralization and nitrification, the nitrate can dissolve in water percolating through the soil and be transported downward into groundwater aquifers. As stated in the "Identification and Evaluation of Methods for Determining Sources of Nitrate Contamination in Groundwater: Guidance Manual" by Rolston, et. al. (Guidance Manual), it can take anywhere between 10 to 100 years for nitrate to travel through the vadose zone and reach groundwater. The vertical migration of nitrate is dependent on the amount of water infiltrating the soil, the soil type, and the depth to groundwater.

Because it may take a considerable amount of time for nitrate to be transported to groundwater, nitrates found in groundwater today may have originated from previous sources which are not reflected in current land uses. Though some practices which generate nitrate have been discontinued, groundwater quality may still be affected over time due to the transport of dissolved nitrates in water percolating through the soil. The time required for the movement of nitrate from the ground surface to groundwater depends on local conditions related to precipitation, transport in soil, plant nitrate uptake, and other processes. The nitrates which are found in groundwater today may have been released from the soil over several years or decades. Thus, soil containing high nitrate concentrations may still be considered sources of nitrate contamination to groundwater even though the practices that originally released the nitrogen to the soil have been discontinued.

NONPOINT SOURCES OF NITRATE IN SOIL AND GROUNDWATER

A nonpoint source of pollution to soil and groundwater occurs when the locations of a number of small sources are so close together that the "point" of pollution is untraceable to a specific point or location such as a discharge pipe or a percolation pond. Nonpoint sources may also be those sources which have no permits or which are not regulated by governmental agencies. Two major nonpoint sources of nitrate have been identified in various scientific publications, and have been found in Llagas Basin. These sources are (1) residential areas served by septic tanks and (2) agricultural areas. Other minor nonpoint sources, such as fertilized residential landscaping, are also present in the study area.

POINT SOURCES OF NITRATE IN SOIL AND GROUNDWATER

A point source is a source which is traceable to a specific point or location such as a percolation pond, a manure pile, or a discharge pipe. Point sources may also include those sources that can be permitted and regulated by governmental agencies.

The types of point sources found in the study area have changed over time. Many dairies were present in the early 1980s, but only four dairy operations remain in the study area today. Conversely, greenhouse operations were not as common in the 1970s as they are now. Also, as the basin becomes increasingly urbanized, more nitrogen-containing waste water is expected to be released into the environment from septic tanks and waste water treatment plants and less nitrogen is expected to be released from agricultural activities.

Studies completed in various areas of California and the United States have identified which types of point sources have the greatest potential for affecting soil and groundwater. Listed below are some of these identified point sources, which are also found in Llagas Basin.

- Dairies
- Cattle feed lots
- Egg farms
- Mushroom farms and composting operations
- Food packing operations
- Wineries
- Cogeneration facilities
- Sewage treatment facilities
- Sewage disposal pits
- Greenhouse operations

LIMITATIONS OF SOURCE AREAS IDENTIFICATION

This portion of the Llagas Basin Nitrate Study is focusing on identifying representative source areas in the basin from each nonpoint and point source category. Identification of all the source areas and categories that are, or have been, present in the basin was limited by the nature and quality of the available data from land use maps, aerial photographs, and reports. When a source type was identified as potentially existing in the basin, efforts were made to use other information sources to confirm whether the source type actually exists or existed. While some minor potential sources of nitrates may have been overlooked, the District feels confident that all major sources of nitrate have been identified in this report.

Also, this phase of the study is limited to evaluating which types of nitrate sources exist or have existed in the basin, and estimating nitrogen loadings from each identified source. Future phases of the study will provide additional results which will be used to develop nitrate management strategies and to prepare an overall study report.

Due to the nature, extent, and number of potential nitrate sources in Llagas Basin, it is difficult to determine the exact amount of nitrogen loading contributed by each particular source. Detectable concentrations of nitrate discovered in a well today may be from a single source, or from a combination of sources from either the past or the present.

CONCLUSIONS

Although exact nitrogen loadings from each source could not be calculated, relative contributions from each source were calculated. The results indicate that commercially fertilized agricultural lands and septic tank areas have been and continue to be two of the most significant sources of nitrate contamination; feed lots and egg farms can be significant point sources if proper waste management is not carried out; and greenhouse operations appear to be a potentially significant source.

Future land use in the area will affect nitrate loading. As the area becomes more urbanized, additional septic waste will be generated from non-sewered residential development, but less fertilized agricultural land will exist. Depending on the type of agricultural land converting to residential, the nitrate loading may increase or decrease. If adequate nitrate management practices are not implemented in order to reduce the total nitrogen loading to the basin, nitrate concentrations in the groundwater of the basin can be expected to remain high, continuing to adversely affect the utilization of groundwater as a source of drinking water.

II. INTRODUCTION

The Llagas Groundwater Basin Nitrate Study is being conducted by the Santa Clara Valley Water District (District) with partial funding from the State Water Resources Control Board (SWRCB) because the District has observed a general trend of increasing nitrate concentrations in Llagas Basin groundwater. The purpose of this phase of the study is to identify and attempt to quantify the sources of nitrate present in Llagas Basin. Subsequent phases of the study will focus on collecting current nitrate concentration data to verify long term trends and developing and recommending an implementation plan for the prevention and control of nitrates.

The southern portion of Santa Clara County, including the cities of Morgan Hill and Gilroy, and the area of San Martin, depends solely on the groundwater from Llagas Basin for its drinking and irrigation water supply. Figure 1 shows the location of the Llagas Basin study area. Current land use distribution in the Llagas Basin area is as follows: about 40 percent agricultural area, 25 percent Urban Service area, 20 percent Rural Residential area, and 5 percent parks and open space. The remaining 10 percent of the land has various land use classifications such as Public Transportation, Educational/Institutional, and Public Facilities. These percentages are based on Santa Clara County's 1991 "Land Use Plan" and have been verified by Santa Clara County Department of Planning and Development staff (personal communication, 1993).

NITRATE HEALTH EFFECTS

The present Maximum Contaminant Level (MCL) for nitrate in drinking water is 45 milligrams per liter (mg/l), as promulgated by the United States Environmental Protection Agency (USEPA). Drinking water supplies with concentrations exceeding this level are considered out of compliance, and require treatment and/or alternative supplies.

In Llagas Basin, numerous wells have exceeded the federal MCL of 45 parts per million (ppm). As outlined in the District's "Nitrate Data Review" report, one third of the wells that have been sampled in Llagas Basin contained nitrate in concentrations above the 45 ppm MCL. Nitrate concentrations exceed 100 ppm at several locations. Elevated nitrate concentrations are a concern because of the susceptibility of infants to methemoglobinemia (blue baby syndrome) resulting from exposures to higher levels of nitrates in water. In addition, research is being done to determine whether excess nitrates in food and drinking water might also have long term carcinogenic (tendency to cause cancer) or teratogenic (tendency to cause fetal malformations) effects on exposed populations.

FORMATION AND TRANSPORT OF NITRATES

Nitrate is produced when compounds which contain nitrogen (human and livestock waste, agricultural fertilizers, etc.) are introduced into the environment and transformed into nitrate in the soil via mineralization and nitrification. Mineralization is the process of organic nitrogen compounds being transformed into inorganic nitrogen compounds such as ammonium salts. Nitrification is the process of bacteria transforming those inorganic nitrogen compounds into nitrates. Except for certain chemical reactions that form minor amounts of nitrate from oxides of nitrogen in the atmosphere, this biological nitrification of nitrogenous compounds is the sole source of nitrate in the environment.

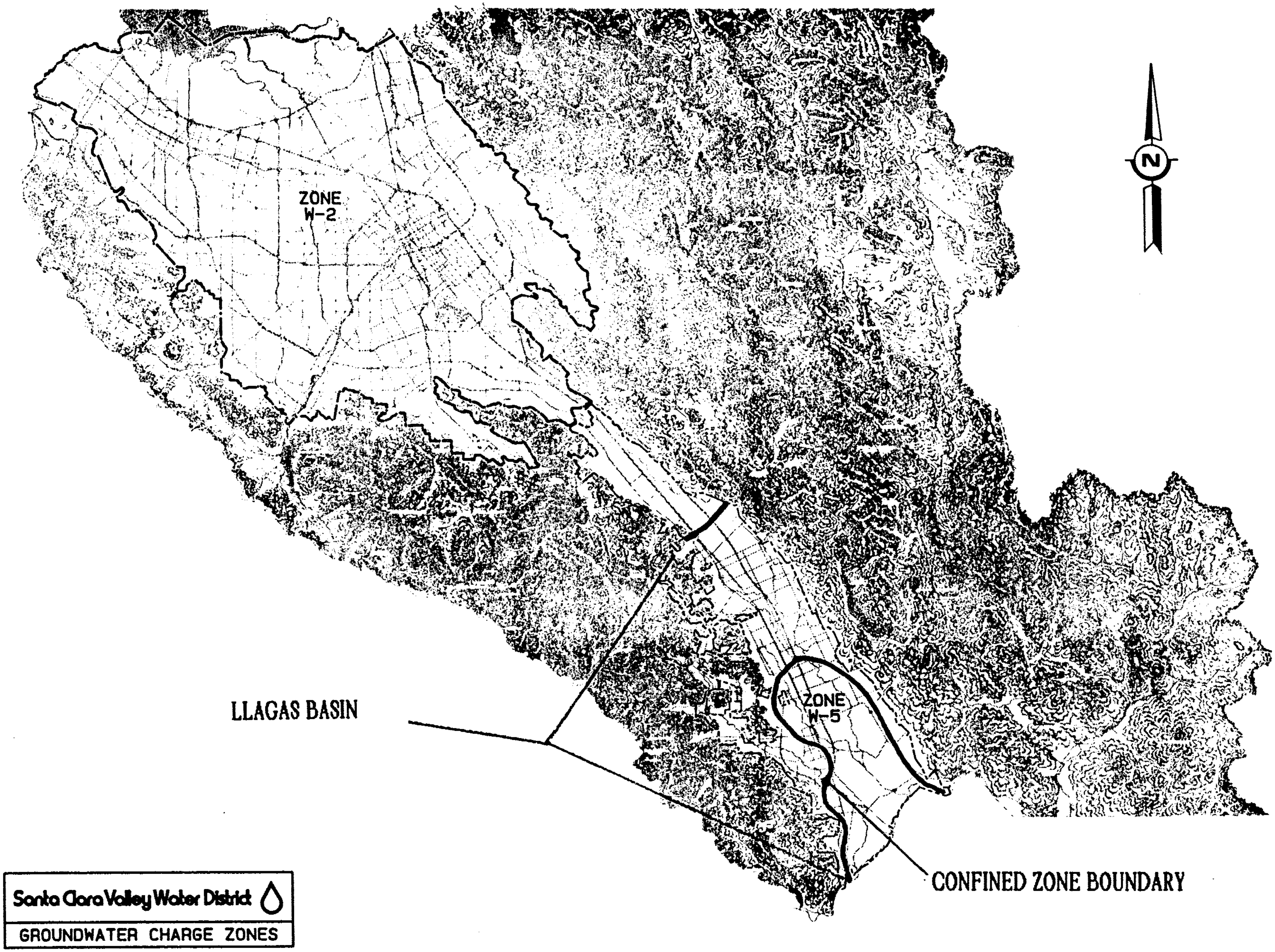

FIGURE 1: SANTA CLARA VALLEY AND LLAGAS BASIN

Nitrogen is introduced into the environment from a variety of sources. In a 1976 study conducted by Miller and Smith for the San Joaquin River Basin in the San Joaquin Valley, California, seven primary nitrogen sources were identified. The sources included municipal wastes, industrial wastes, livestock manures, agricultural fertilizers, waterborne nitrogen (nitrogen bearing water entering the study area via stream and groundwater flow), nitrogen fixation (reduction of nitrogen gas to ammonia and organic nitrogen by various microorganisms), and precipitation. Results from the study reported nitrogen contributions from the various sources as follows: · municipal wastes—2 percent, industrial wastes—4 percent, livestock manures—18 percent, agricultural fertilizers—43 percent, waterborne nitrogen—13 percent, nitrogen fixation—18 percent, and precipitation—2 percent. Because we find many of the same land use types in Llagas Basin, we have found that many of the same sources of nitrogen are significant contributors to Llagas Basin. It should be noted, however, that Llagas Basin is more urbanized than San Joaquin Basin and therefore, the relative amounts of nitrogen introduced by municipal wastes (i.e. septic tank and wastewater treatment plant effluent) is expected to be higher.

Once nitrogen containing compounds have been transformed into nitrate through mineralization and nitrification, the nitrate can dissolve in water percolating through the soil and be transported downward into groundwater aquifers. It can take a considerable amount of time for nitrate to reach groundwater because the vertical migration of nitrate is dependent on the amount of water infiltrating the soil, the soil type, and the depth to groundwater. After nitrates reach groundwater they typically move in the direction of groundwater flow.

OVERALL STUDY TASKS AND STATUS

The study started on October 1, 1991, and is scheduled to be completed on March 31, 1995. The agreement between the SWRCB and the District for the study consists of the following eleven tasks:

- Manage and Administer Project. This is an ongoing task.
- Conduct Public Participation Meetings. One out of two meetings has been held.
- Develop Quality Assurance Project Plan. This task has been completed.
- Review Historical Nitrate Data. This task has been completed.
- Identify Nitrate Source Categories[1]
- Select Sample Collection Points
- Collect and Analyze Samples and Data
- Review Legislative Mechanisms and Management Plan to Control the Nitrate Problem
- Prepare Implementation, Institutional, and Financial Plans
- Prepare Draft Final Report
- Prepare Final Report

Two of the tasks have already been completed. These tasks include developing a Quality Assurance Project Plan, and completing the Nitrate Data Review report, which summarized and evaluated nitrate data from previous studies. The remaining tasks include selecting wells to sample groundwater from, sampling and analyzing groundwater from those wells, and developing a plan for the prevention and control of nitrates. A review of existing and potential legislative mechanisms for controlling nitrates is being performed with input from a Technical Advisory Committee (TAC). The TAC is composed of representatives from the SWRCB, the Central Coast Regional Water Quality Control Board (CCRWQCB), the cities of Gilroy and Morgan Hill, the County of Santa Clara, the agricultural community, and the public.

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[1] Present status of study

IDENTIFICATION OF NITRATE SOURCES

The primary focus of this portion of the Llagas Groundwater Basin Nitrate Study is to present a review and summary of nitrate sources that either exist or have existed in Llagas Basin. This report also discusses those sources that may either remain or become significant sources in the future. There are two main purposes for identifying these sources. The first purpose is to help the District select locations for the sample collection portion of the study. The second purpose is to help the District determine how widespread and significant these sources may be in the basin in order to determine appropriate technical and/or legislative measures for reducing nitrate impacts on drinking water supplies.

In order to determine the location of past and present sources of nitrate, aerial photographs and maps were studied, groundwater quality reports were reviewed, and oral interviews were conducted. As a result, two major categories of nonpoint sources and ten categories of point sources were identified. The nonpoint sources and most point sources (greenhouses, dairies) were generally found to be distributed throughout the basin while some point sources (food packing operations, wineries) were found to be clustered in the vicinity of the commercial centers. Identification of future sources of nitrate was based primarily on a review of projected land use patterns for the basin.

LIMITATIONS OF SOURCE AREAS IDENTIFICATION

This portion of the study focuses on identifying representative source areas in the basin from each nonpoint and point source category. Identification of all the nitrate sources in the past, present, and projected for the future was limited by the availability of data from land use maps, aerial photographs, and reports which did not provide a full picture of the basin. When a source type was identified as potentially existing in the basin, efforts were made to use other information sources to confirm whether the source type actually exists or existed. While some minor potential sources of nitrate may not have been identified, the District feels confident that all significant sources of nitrate have been identified in this report.

III. GEOLOGY AND HYDROGEOLOGY OF LLAGAS BASIN

The geologic history of Llagas Basin has resulted in a complex hydrogeologic system consisting of confined and unconfined aquifers. As shown in Figure 1, Llagas Basin continues southeasterly from the southern end of Coyote Valley at the interconnecting topographic divide to the southern boundary of the County at the Pajaro River. The bulk of the alluvial materials washed into the basin is alluvial fan materials from Coyote Creek splaying southward from the topographic divide. Other major sources of alluvial fill material that constitute the basin are from Llagas Creek and Uvas Creek from the Santa Cruz Mountains which bound the west side of the basin. Small alluvial fans from small ephemeral drainage occur along both elevated lateral edges of the basin. As shown in Figure 2, the depth of alluvial fill and the underlying Santa Clara formation varies from about 500 feet at the northern divide to greater than 1,000 feet at its southern end. The Purissima Formation which underlies the alluvium and the Santa Clara Formation is, in part, water bearing in neighboring counties, but is not tapped here.

In general, the basin is divided into three hydrographic units. The northern portion of the basin and the elevated lateral edges of the basin constitute the forebay and the southern flat interior portion is divided into upper and lower aquifer zones (similar to Santa Clara Valley Basin).

The forebay comprises mostly aquifer materials with discontinuous aquitards, is unconfined, and is the principal basin recharge zone. Recharge is from subsurface inflow from Coyote Valley where a groundwater mound occurs beneath the topographic divide, from deep percolation of streams, principally along Llagas Creek north of Rucker Avenue, and from Uvas Creek west of U.S. Highway 101. Minor amounts of recharge can also be attributed to rainfall, irrigation returns, and from the subsurface flow from nonwater-bearing formations that laterally bind the basin. Within the forebay, groundwater generally flows from the topographic divide southeasterly down the basin toward the flat south central part of the basin.

Confining conditions which create both upper and lower aquifer zones occur in the flat southern interior portion of the basin and continue southerly past the County line into the Hollister Basin. The separation between the upper and lower aquifers is formed by a continuous regional aquitard that occurs at varying depths from about 20 to 100 feet, and extends from approximately Rucker Avenue to the south basin boundary. The thickness of this major aquitard varies from about 40 to 100 feet. Both upper and lower zones are stratified with aquifers and aquitards.

Groundwater in the upper aquifer zone is unconfined in the uppermost aquifer and confined or partially confined in deeper aquifers. The depth to groundwater in this zone is usually shallow and generally flows southeasterly, to the Pajaro River. Recharge to the upper aquifer zone is from surface sources and from subsurface flows from the forebay.

Numerous individual aquifers occur in the lower aquifer zone. Groundwater in these aquifers is confined and generally flows to the southeast except where the regional gradient is interrupted by pumping troughs. Subsurface flow from the forebay recharges these aquifers. From the mid-1800s, wells tapping the southern portion of this zone, south of Old Gilroy, were flowing artesian wells (Clark, 1924). With a greater amount of pumping in more recent times, the artesian pressures have declined and now only a few of the wells in the southernmost portion of the basin flow under pressure; these are only on a seasonal basis.

In Llagas Basin most of the waters are pumped from the forebay and lower aquifer zones, though many of the wells in the flat southern interior portion of the basin pump from both upper and lower aquifer zones[2].

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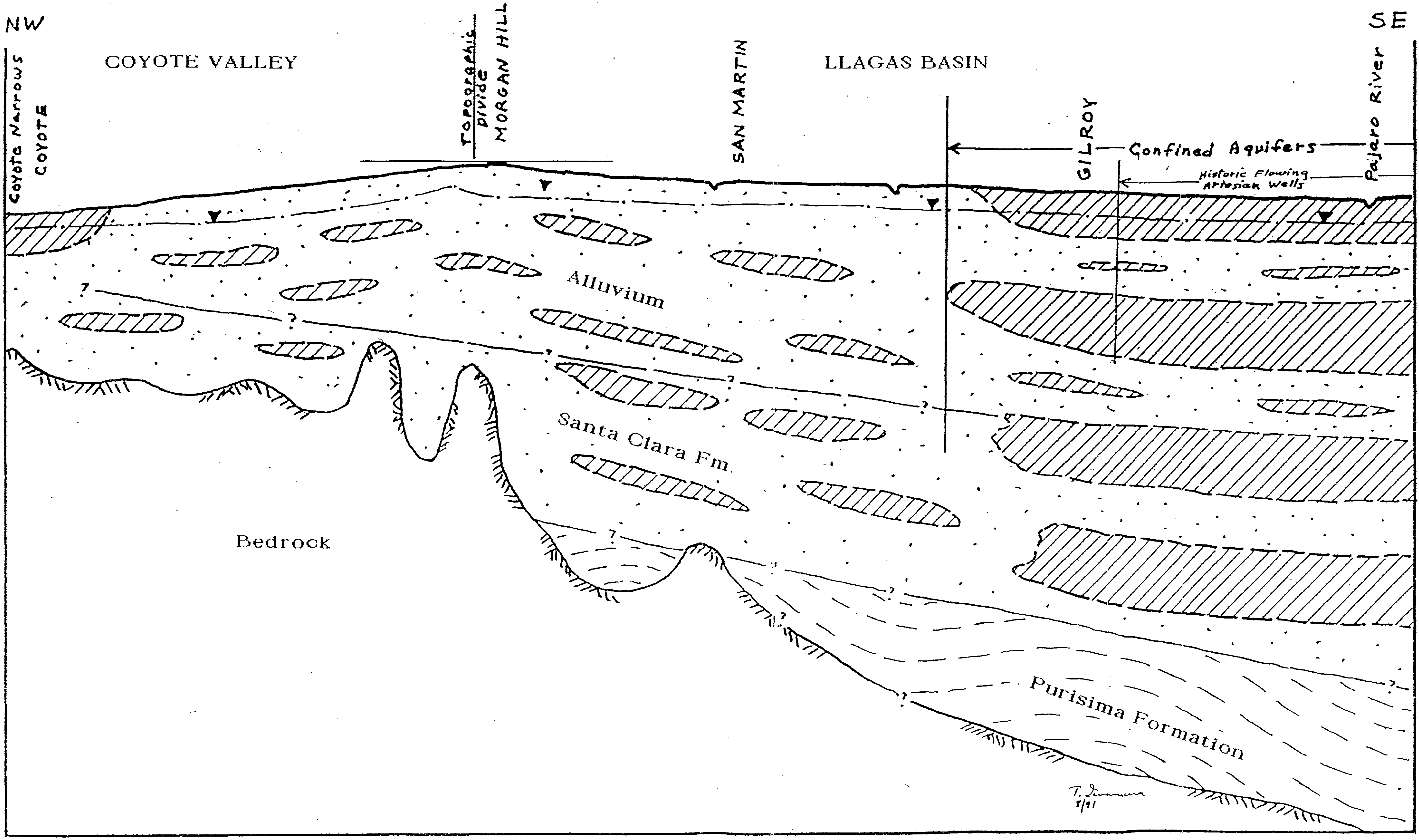
[2] Additional discussion of Llagas Basin geology and hydrogeology is available in the May 1981 "Evaluation of Groundwater Resources: South San Francisco Bay. Volume IV: South Santa Clara County Area," by the Department of Water Resources (Bulletin 118-1).



Not to scale

FIGURE 2: DIAGRAMMATIC CROSS SECTION
COYOTE VALLEY - LLAGAS BASIN

IV. NONPOINT SOURCES OF NITRATE

A nonpoint source of pollution to soil and groundwater occurs when the locations of a number of small sources are so close together that the source of pollution is untraceable to a specific point or location such as a discharge pipe or a percolation pond. Sometimes nonpoint sources are also considered to be those sources which have no permits or which are not regulated by governmental agencies. A nonpoint source of nitrate occurs when substances containing nitrates or other nitrogen-based compounds which can be broken down into nitrate are applied over a large land area.

Nonpoint sources are important to consider in relation to nitrate occurrences in Llagas Basin. A significant contribution from such sources in the past, present, and future is likely in the study area.

Two major types of nonpoint sources of nitrate have been identified in Llagas Basin. They are residential areas served by septic tanks and nitrogen-fertilized agricultural lands. Other fertilized areas, such as golf courses and landscaped urban areas, as well as natural sources of nitrogen have also been identified as nonpoint sources in the study area. The remainder of potential sources of nitrate in the study area can be considered point sources and are discussed in the following section.

It is difficult to accurately determine the exact amount of nitrate that would leach to groundwater from each source mainly because the processes of nitrogen transformation, including volatilization, denitrification, and assimilation, are not well understood (Rolston et al, 1994). However, reasonable estimates of maximum potential nitrate loading from each source can be made using various empirical and theoretical scientific information, as well as professional judgement. Standard practice is to calculate the potential nitrogen loading (expressed in terms of total nitrogen) from each source and to use those values as the maximum amount of nitrate that could leach to groundwater from each identified source. This correlation is justified by the fact that nitrogen is present predominantly as the nitrate ion, and as nitrite or ammonium only to a minor degree.

Calculations to estimate potential nitrogen loadings are based on data and information from the Central Coast Regional Water Quality Control Board (CCRWQCB), the County Department of Agriculture, the Santa Clara County Department of Planning and Development, the State Department of Water Resources (DWR), the California Department of Food and Agriculture (CDFA), census reports, and information from experts and technical literature. In particular, sample calculations and other pertinent data presented in the Guidance Manual at UC Davis are used wherever appropriate and/or applicable. A summary of estimated potential nitrogen loading from each source is shown in Table 6; sample calculations are provided in Appendix B. The following paragraphs present the District's basis for using the values found in the sample calculations.

AGRICULTURAL AREAS

Many studies have contended that on a nation- and state-wide basis, agricultural activities are the main source of nitrate-contaminated groundwater (Bouchard et al, 1992; Anton, et al., 1988). The leaching of nitrogen from commercial fertilizer applied to agricultural lands is thought to be a significant nitrate source in Llagas Basin. It has contributed to the problem for the longest time as shown by the estimates of potential nitrogen loadings by commercial fertilizer application for the period from 1967 to 1990 in Table 6.

From 1960 to the early 1970s, when fertilizer was less costly, fertilizer may have been applied in excess of the crop or plant's capacity to take up the fertilizer's nitrogen. At that time, little was known about the nutrient uptake rates of plants, and overfertilization was less costly than running the risk of obtaining low crop yields. As a result of this overfertilization, even more nitrogen was able to convert to nitrate and leach.

AGRICULTURAL LANDS FERTILIZED BY COMMERCIAL FERTILIZER

Calculations to estimate potential nitrogen loadings by nitrogen-fertilized agricultural lands are based on data from DWR land use surveys, Agricultural Chemical Usage Reports by United States Department of Agriculture (USDA), Survey of Fertilizer Use in California by the Division of Agricultural Sciences at the University of California, and information from technical literature and experts in this field. Specifically, the following information and assumptions were used to estimate potential nitrogen loadings due to the application of nitrogen-based commercial fertilizer:

1. The crop types and acreage in the study area are shown in Table 1 for the years 1967, 1978, and 1990. This information was compiled from the DWR land use survey data which enables us to accurately determine the acreage of each different crop grown in the study area. The DWR land use surveys have been conducted in order to determine urban and agricultural water needs. Every major water using county is resurveyed approximately every seven years. The acreage of each crop type are determined and summarized by quad, county, irrigation district, and hydrologic area in each land use survey.

2. The nitrogen fertilizer application rates for vegetable crops were provided by Dr. Timothy Hartz of University of California, Davis (Table 1) and these numbers represent reasonable estimates of the average application rates used by the growers in Santa Clara Valley since 1977. According to Dr. Hartz (personal communication, 1994), the use of nitrogen fertilizer increased by approximately 20% during the time period between 1967 and 1977, and has essentially remained constant to the present. Therefore, application rates for the year 1967 are 80 percent of those used for the years 1978 and 1990.

   The statewide average nitrogen fertilizer application rates compiled in the Agricultural Chemical Usage 1991 Fruits and Nuts Summary by the USDA are used for fruit and nut crops for the years 1978 and 1990. As the case with vegetable crops, application rates for the year 1967 are 80 percent of those used for the years 1978 and 1990.

   The nitrogen fertilizer application rates for field crops in the year 1967 are based on the statewide average application rates compiled in the Survey of Fertilizer Use in California 1973 by the Division of Agricultural Sciences at the University of California. Again, application rates for the year 1967 are 80 percent of those for the years 1978 and 1990.

3. The nitrogen content of nitrogen-based fertilizers ranges widely from 3 percent to 80 percent (Brady, 1974). Based on discussions with the county farm advisor and local farmers of the study area (personal communication, 1994), a typical nitrogen content of approximately 30 percent was used. The nitrogen application rates for different crop types shown in Table 1 are determined based on the nitrogen fertilizer application rates and the estimated nitrogen content.

TABLE 1
Estimated Potential Nitrogen Loadings to Groundwater by Commercial Fertilizer Application

CROP TYPE	N-FERTILIZER APPLICATION RATE (lbs/acre/year)			NITROGEN[1] APPLICATION RATE (lbs/acre/year)			ACREAGE OF IRRIGATED LAND[2] (acres)			POTENTIAL[3] NITROGEN LOADING (lbs/year)		
	1967	1978	1990	1967	1978	1990	1967	1978	1990	1967	1978	1990
FIELD CROPS[4]												
Safflower	81	97	97	24	29	29	0	0	172	0	0	1,496
Sugar Beets	129	155	155	39	46	46	244	439	793	2,855	6,058	10,943
Corn	170	204	204	51	61	61	630	95	1,294	9,639	1,738	23,680
Grain Sorghums	118	142	142	35	42	42	176	0	14	1,848	0	176
Beans (dry)	51	61	61	15	18	18	0	1,105	232	0	5,967	1,252
Alfalfa	20	24	24	6	7	7	313	440	431	563	924	905
Grain, Hay	92	110	110	28	33	33	21	847	4,681	176	8,385	46,342
Oats	72	86	86	22	26	26	0	0	199	0	0	1,552
Pasture	64	77	77	19	23	23	1,189	775	472	6,777	5,348	3,257
VEGETABLE CROPS[5]										0	0	0
Asparagus	120	150	150	36	45	45	0	222	87	0	2,997	1,175
Beans (green)	48	60	60	14	18	18	1,074	16	177	4,511	86	956
Cole Crops	160	200	200	48	60	60	101	0	50	1,454	0	900
Carrots	96	120	120	29	36	36	0	41	0	0	443	0
Lettuce	120	150	150	36	45	45	18	832	16	194	11,232	216
Melons, Squash	80	100	100	24	30	30	1,137	1,461	393	8,186	13,149	3,537
Onions, Garlic	144	180	180	43	54	54	509	989	1,142	6,566	16,022	18,500
Tomatoes	144	180	180	43	54	54	4,418	5,403	2,847	56,992	87,529	46,121

TABLE 1
Estimated Potential Nitrogen Loadings to Groundwater by Commercial Fertilizer Application
(continued)

CROP TYPE	N-FERTILIZER APPLICATION RATE (lbs/acre/year)			NITROGEN[1] APPLICATION RATE (lbs/acre/year)			ACREAGE OF IRRIGATED LAND[2] (acres)			POTENTIAL[3] NITROGEN LOADING (lbs/year)		
	1967	1978	1990	1967	1978	1990	1967	1978	1990	1967	1978	1990
Strawberries	189	236	236	57	71	71	143	168	420	2,445	3,578	8,946
Peppers	176	220	220	53	66	66	1,114	1,228	1,268	17,713	24,314	25,106
FRUITS & NUTS[6]										0	0	0
Apples	70	88	88	21	26	26	41	7	32	258	55	250
Apricots	62	77	77	18	23	23	594	42	0	3,208	290	0
Cherries	68	85	85	20	26	26	667	1,736	619	4,002	13,541	4,828
Peaches, Nectarines	117	146	146	35	44	44	0	0	10	0	0	132
Pears	84	105	105	25	32	32	1,095	263	52	8,212	2,525	499
Prunes	99	124	124	30	37	37	12,367	1,897	711	111,303	21,057	7,892
Walnuts	109	136	136	33	41	41	2,121	1,517	1,010	20,998	18,659	12,423
Vineyards	53	64	64	16	19	19	1,784	1,109	884	8,563	6,321	5,039
Kiwis	207	259	259	62	78	78	0	0	38	0	0	889
TOTAL							29,756	20,632	18,044	276,463	250,218	227,012

Nitrogen Fertilizer Application Rate Source

[1] Assumed nitrogen content in nitrogen-based fertilizer is 30 percent.

[2] Crop acreage data, Department of Water Resources Land Use Survey

[3] Amount of nitrogen available for potential leaching to groundwater after nitrogen losses due to volatilization, denitrification, and plant uptake.

[4] Survey of Fertilizer Use in California 1973, Division of Agriculture Sciences, University of California

[5] Dr. Timothy K. Hartz, Department of Vegetable Crops, University of California at Davis

[6] Agricultural Chemical Usage, 1991 Fruits and Nuts Summary, United Stated Department of Agriculture

4. An estimated nitrogen leaching percentage of 30 percent was used in the calculations. This estimate was based on the fact that the consumption rate of total applied nitrogen via crop uptake typically ranges from 20 to 80 percent (Nitrate Working Group, 1988). From this information, the average, 50 percent, was taken, and then additional processes which affect the total percentage of nitrogen leached was considered. These processes include denitrification and volatilization.

   According to the study of San Joaquin River Basin in the San Joaquin Valley in California, the percentages of nitrogen loss via denitrification and volatilization were 15 percent and 5 percent, respectively (Miller and Smith, 1976). Results from a similar study of Santa Ana River Basin in California showed almost identical percentages for the denitrification (15 percent) and volatilization (4 percent) processes (Ayers and Branson, 1973). It is important to note that there are considerable differences in soil types and climatic conditions between these two river basins, yet similar percentages were derived. Soil types and climatic conditions in Santa Clara Valley are not identical to either San Joaquin or Santa Ana River Basins. However, since similar percentages have been derived regardless of soil types and climatic conditions, it is reasonable for calculation purposes to use the similar percentages for the two processes. Fifteen percent will be used for denitrification and five percent will be used for volatilization. Therefore, a 50 percent average loss of nitrogen due to crop uptake plus a 20 percent loss due to denitrification and volatilization results in a 30 percent estimate for nitrogen loading due to leaching.

   The results of nitrogen loading calculations are shown in Table 1. It appears that the application of commercial fertilizer has been and still remains as a main contributor of nitrogen to groundwater in the study area even though the nitrogen loading from fertilized agricultural lands is decreasing due to the reduction in agricultural acreage and more prudent fertilization practices.

   It is important to note that combined with agricultural use of land, the following two conditions exacerbate nitrate occurrence in groundwater: (1) the presence of sandy soils and (2) crops and plants with shallow root zones. Firstly, sandy soils allow for aerobic conditions which are necessary for nitrification, and allow for quicker percolation of water. Higher application rates are expected since higher watering rates wash out the nitrogen fertilizer from the root zone of the soil. Secondly, crops and plants with shallow root zones offer a smaller area in which nitrogen may be taken up by the plants, and allow more nitrate to continue downward through the soil.

MANURE FERTILIZER APPLICATION

Nitrogen contribution from manure application on cropland in the study area does not appear to be significant. Discussions with the county farm advisor (personal communication, 1994) indicated that no more than 5 percent of animal manure generated is used for crop fertilization in the study area. Calculations were made to estimate potential nitrogen loadings by the application of manure to crop lands. As seen in Table 6, the estimated amount of 8,100 to 26,900 lbs per year is considerably less than that from the application of nitrogen-based commercial fertilizer. Also, it appears to be consistent with the finding that the amount of nitrogen available in all manure has been estimated at about 10 percent of that used in commercial fertilizers (National Research Council, 1978).

OTHER FERTILIZED AREAS

Large lawn areas, golf courses, landscaped urban areas and other fertilized areas may be sources of nitrate in the Llagas Basin area. Nitrogen contributions from these sources could not be calculated as specific data was unavailable for the study area. However, a qualitative evaluation was performed based on information from another study. This study of golf courses on Cape Cod was conducted from 1985 through 1987 and estimated that nitrogen applied to these types of areas averages about 130 pounds per acre per year (Cohen et al., 1990). This is similar to estimated application rates to agricultural land. Groundwater samples collected in that study area exhibited average nitrate concentrations (measured as nitrate) in the range of 0.45 mg/l to 36 mg/l. The study concluded that reduction of nitrogen loading to the surface did have a favorable effect on the nitrate levels observed in groundwater. It was also observed that areas which used slow-release nitrogen fertilizer as opposed to water soluble fertilizer seemed to pose less of a threat to groundwater quality.

Based on information from this study, the District believes that these sources contribute to the nitrogen loading, and that the extent to which they contribute is dependent on the management practices of the various parties involved.

SEPTIC TANK AREAS

Large areas served by septic tanks[3] may be a significant nonpoint source of nitrate. Although a single septic tank is a point source, a large cluster of them may actually act as a nonpoint source. For example, high nitrate concentrations appearing in a well in a relatively densely populated area of San Martin are likely to be untraceable to a single residence's septic tank.

Effluent from a typical household septic tank is estimated to contain up to 70 mg/l of nitrogen in the forms of organic nitrogen and ammonium, and net nitrogen removal is thought to be minimal in septic tanks (State Water Resources Control Board, October 1988; Bouchard, September 1992). In the leach fields, the nitrogen is readily converted to nitrate and subsequently may leach to groundwater. By County ordinance, septic tanks are required to be located 100 feet from water supply wells, and have specific requirements for depth of soil between the leach field and groundwater, depending on the percolation rate of the soil. In San Martin, a five-acre minimum parcel size currently exists for residences which are to be served by septic tanks. However, some parcels smaller than five acres are still using septic tanks as a waste disposal method. Because septic tank ordinances were written primarily to protect against bacteriological contamination, the prevention of nitrate pollution may only be partially addressed.

The groundwater impact due to septic tanks is greatest when residences which are served by septic tanks are situated in close proximity to each other, thereby decreasing the available attenuation zone for pollutants as they migrate towards groundwater, and increasing the concentration of pollutants in the soil and water underneath the leach fields. In other words, the concentration of nitrate in groundwater in septic areas generally increases with the density of septic systems in the area. When septic systems are located in close proximity to each other, the beneficial dilution effect that the fresh groundwater has on the pollutant is diminished, as nearby systems may have already degraded the quality of the aquifer. The attenuation of the pollution before it reaches a drinking water source is therefore compromised (Esmaili and Associates, 1978; Sinton, 1978; Hantzsche and Finnemore, 1992). The areas of San Martin and certain outlying areas of the city of Gilroy and Morgan Hill are the most likely areas to have significant nitrate contributions from septic tanks due to these reasons.

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[3] "Septic tank" in this report refers to septic tanks and their associated leach fields.

Calculations to estimate potential nitrogen loadings by septic tanks in the study area for the years 1970, 1980, and 1990 were made based on data from Santa Clara County Department of Planning and Development population census reports, as well as information from technical literature. Table 2 shows the total number of dwelling units and total populations in the unincorporated portion of the study area.

TABLE 2
Total Number of Dwelling Units and Populations in Unincorporated Area

Year	1970	1980	1990
Dwelling Units[1]	4,010	4,565	4,910
Population	11,300	12,800	13,800

[1] Average Number of Persons per Dwelling Unit in Santa Clara County is 2.81 (1990 Population Census).

It is assumed that (1) all the dwelling units in the unincorporated area are served by septic tanks, (2) 40 to 80 percent of the nitrogen leaving the septic tank will potentially reach groundwater, and (3) the daily nitrogen loading rate per capita from domestic wastewater ranges from 12 to 17 grams of N per person per day (Rolston et al., 1994). According to the Guidance Manual by Rolston et al., the nitrogen leaching percentage of 40 to 80 percent was determined from the estimated nitrogen losses of 20 to 35 percent due to volatilization and 0 to 25 percent due to denitrification. Table 3 shows the results of the calculations.

The increase in nitrogen loadings contributed by septic tanks from 1970 to 1990 is primarily attributable to the conversion of land in the study area from agricultural use to rural residential use, as indicated by the increase of dwelling units over the same time period.

TABLE 3
Estimated Potential Nitrogen Loadings to Groundwater by Septic Systems

Year	Nitrogen Loadings (thousands pounds)	Average Nitrogen Loadings
1970	44 - 123	84
1980	49 - 140	94
1990	53 - 151	102

RAINWATER

Rainwater is a potential source of nitrate contamination to Llagas Groundwater Basin. Rainwater is also a transporter of nitrates from the soil to groundwater, but our discussion focuses on rainwater as a source. In order to accurately calculate nitrogen loadings from rainwater as a source, an intensive study should be performed reviewing hydrologic and water quality records. Such a study is beyond the scope of this project. However, some rough estimates of the nitrogen loading due to rainwater were made (Appendix B). The actual amount of nitrogen-laden rainwater that leaches to groundwater depends on several factors such as the amount of nitrogen in rainwater; antecedent moisture conditions of the soil;

the amount of runoff, evapotranspiration, and depression storage; and the overall intensity, frequency, and duration of rainfall events.

In general, the total volume of nitrogen-laden rainwater per year was calculated. Then, knowing that a large percentage of the rainwater would be lost due to typical hydrologic processes such as runoff and evaporation, the volume of nitrogen-laden rainwater that could infiltrate the soil was calculated. Similar to other source calculations, nitrogen losses were then estimated and subtracted from the total volume of nitrogen-laden rainwater that infiltrated the soil. The final result was the maximum amount of nitrogen-laden rainwater that could leach to groundwater. More specifically, the following information was used:

1. An average total nitrogen content of rainwater equal to 1.3 mg/l was used (University of Illinois, 1997). Other reports have described nitrogen content of average rainwater as "trace." These values are similar to the natural background concentrations of nitrate in groundwater.

2. An average rainfall of 20.80 in/yr. was used based on information from District rainfall records.

3. The area of Llagas Creek watershed is approximately 89.47 square miles. This information was obtained from District flood control records.

4. A 10 percent infiltration rate was used based on conversations with District staff (personal communication, 1994).

5. A 50 percent loss due to crop uptake was used. This is the same value used to calculate nitrogen loading due to agricultural areas.

6. A 10 percent loss due to denitrification was used. This value is based on the minimum amount of denitrification that occurs as a result of the other sources of nitrate.

As shown by the calculations in Appendix B, nitrogen loading contributions due to rainfall are estimated at 14,000 pounds per year. Based on these calculations, rainwater does not appear to be one of the main contributors of nitrate to Llagas Basin.

NATURAL NONPOINT SOURCES

Soil organic matter of crop lands and natural areas in grass and forest is another natural nonpoint source. According to Rolston et al., however, mineralization of soil organic matter does not appear to be a significant contributor of nitrate in the groundwater of the Central Coast area, which includes this study area.

DOMESTIC LIVESTOCK

Because of high nitrogen content, manure generated by domestic livestock such as horses, sheep and lambs can be a potentially significant source of nitrate contamination.

There are no quantitative data available for nitrogen loadings to groundwater in the study area by domestic livestock. However, it appears that for the study area, manure from domestic livestock is not a significant contributor of nitrate because (1) most domestic livestock are raised on range lands and pasture where wastes are easily assimilated into the soil without significant groundwater and surface water contamination (Miller, 1980), and (2) the number of domestic livestock is generally small and the land over which they live is generally large.

Currently, waste management for large size animal confinement operations, such as dairies, egg farms, and feed lots, is regulated under the CCRWQCB's Basin Plan. However, the CCRWQCB can also regulate waste management of any waste discharger, including domestic livestock owner, regardless of size by requiring waste discharge permits or granting a waiver with the implementation of best management practice.

ILLEGAL DISPOSAL OF WASTES INTO WELLS

Illegal disposal of nitrogen-containing wastes, such as fertilizer, into wells is a potential source of nitrate contamination in groundwater. The prevalence and severity of such practices is unknown. However, based on conversations with District field personnel (personal communication, 1994), over the last 5 to 10 years, the practice of "chemigation" appears to be increasing in the agricultural community. Currently, many farmers practice "chemigation;" they use on-line fertilizer tanks to feed liquid fertilizer into their irrigation lines. The fertilizer tanks usually hold 100-200 gallons of fertilizer and are hooked up near the wellhead with little to no backflow prevention. The absence of appropriate backflow prevention devices allows the fertilizer that had been sucked into the irrigation line to flow back through the irrigation line and into the well when the pumps are shut off.

Also, dry wells have been used for illegal disposal of wastes. Dry wells, or storm water infiltration devices, are typically constructed as a 10 to 20 feet deep boring of 2 to 4 feet diameter filled with cobbles and rocks and lined with a perforated corrugated metal pipe. When used for illegal disposal of chemicals, such as fertilizer, they allow the chemicals to enter the subsurface directly into groundwater. The prevalence and severity of such disposal is unknown and difficult to estimate.

PAST NONPOINT SOURCES OF NITRATE

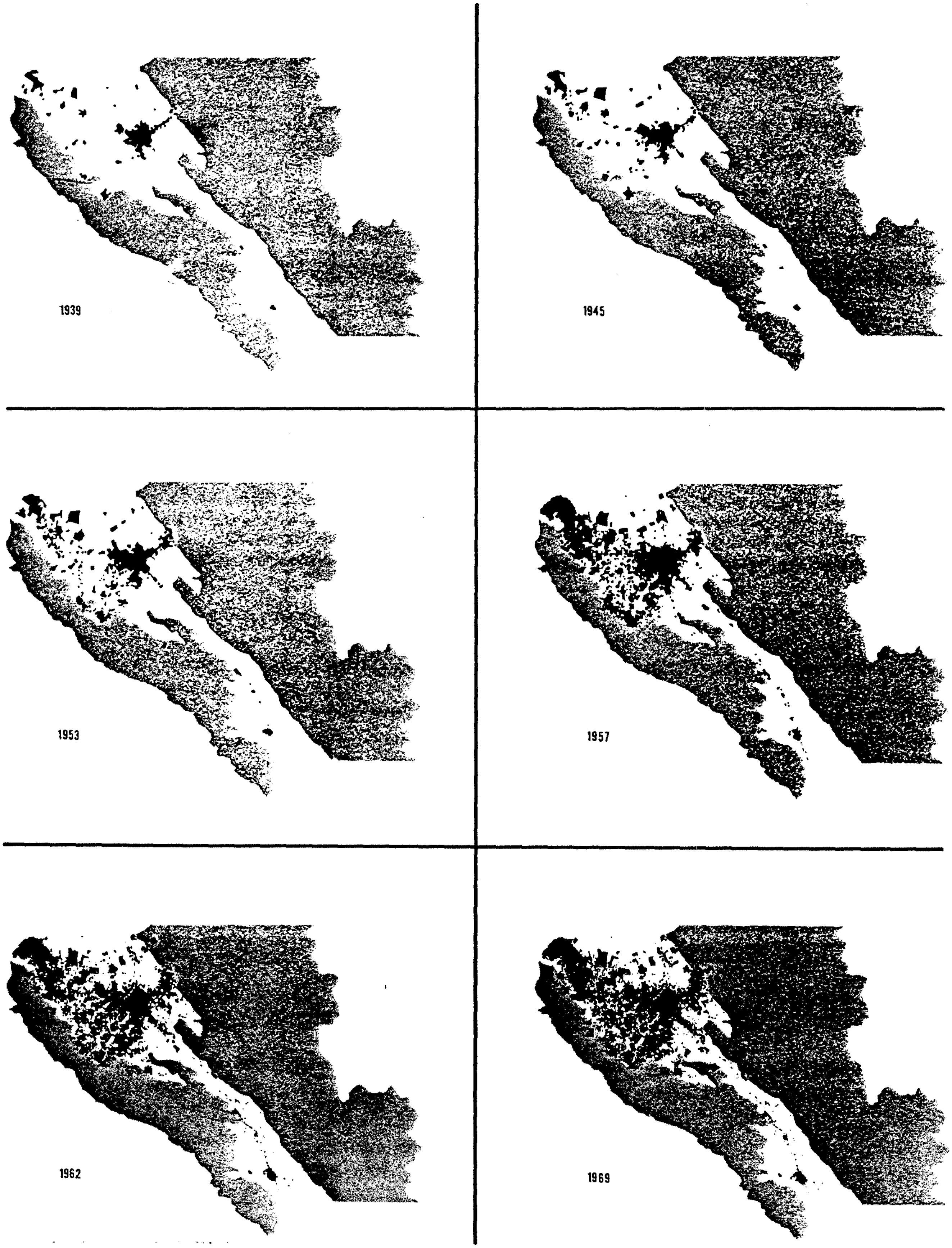
The lag time between the application of nitrogen at the ground surface and its appearance as nitrate in groundwater can be significant. It has been estimated that in fine-grained soils, it may take 20 or more years for nitrogen to leach 100 vertical feet (Brown and Caldwell, 1981). Therefore, it is important to consider types of land use which may have been sources of nitrogen in the past. Figure 3 illustrates historic patterns of urbanization in Santa Clara County from 1939 to 1969. Figure 4 shows land use in Santa Clara County for 1981. From these maps, a few facts are noticeable relative to past nitrate sources. Urban areas have been increasing in recent decades, especially in the Morgan Hill and Gilroy areas. Also, agricultural areas have been decreasing. This most likely helped reduce total nitrogen loading in the study area as fertilized areas are decreased.

PRESENT NONPOINT SOURCES OF NITRATE

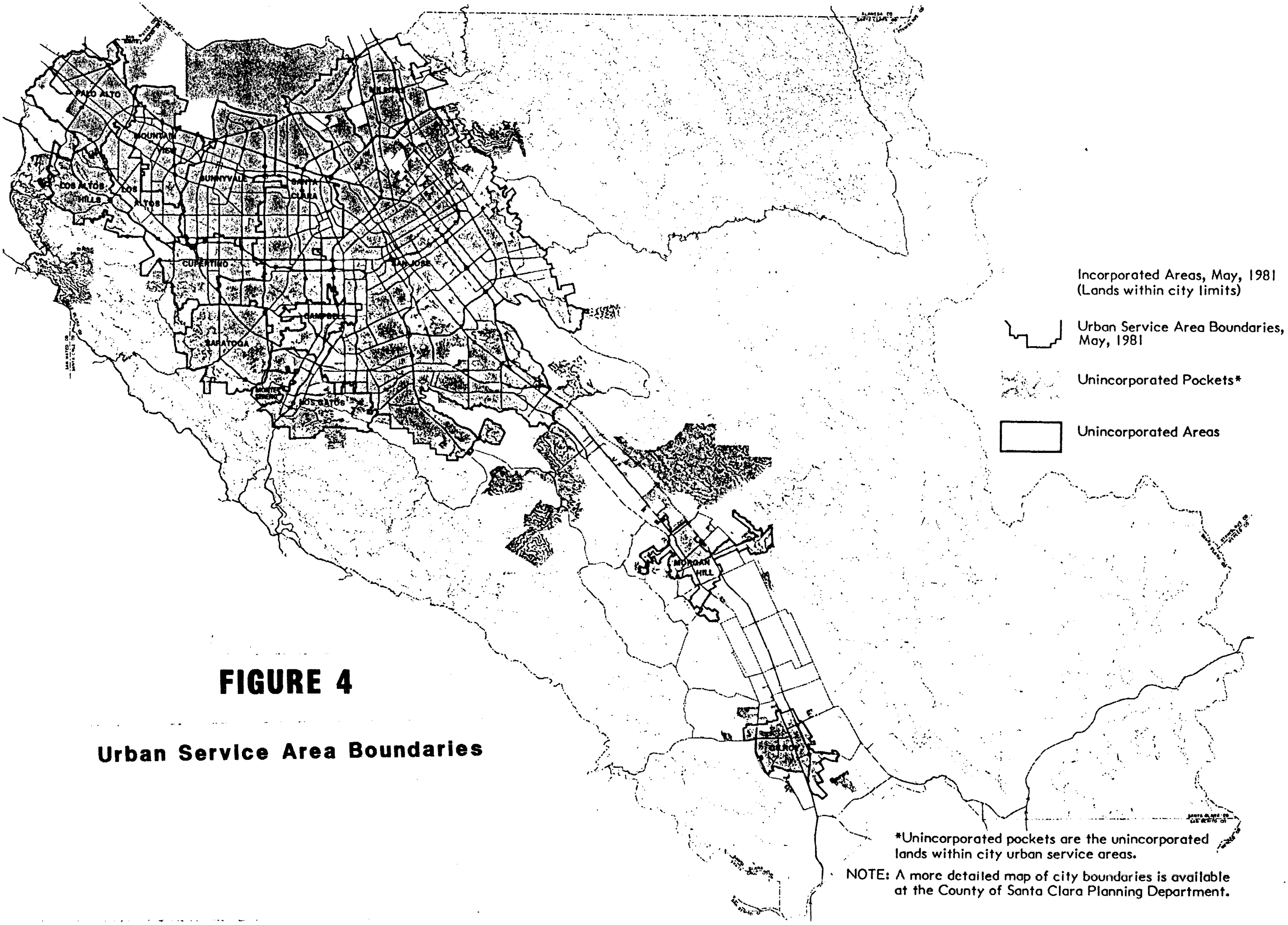
Nitrate contamination from nonpoint sources is currently occurring in Llagas Basin. Agricultural lands fertilized by nitrogen-based commercial fertilizer appears to be one of the main nonpoint sources as well as high density septic tank areas. The current loadings support a decreasing trend in nitrate loadings due to nitrogen-based commercial fertilizer and a slight increasing trend due to high density septic tank areas. While other nonpoint sources, such as rainwater, manure fertilized agricultural lands, etc., contribute only relatively minor amounts of nitrate to Llagas Basin, they still nevertheless affect groundwater quality.

FIGURE 3

HISTORIC PATTERNS OF URBAN DEVELOPMENT, SANTA CLARA COUNTY



Source: Santa Clara County Planning



*Unincorporated pockets are the unincorporated lands within city urban service areas.

NOTE: A more detailed map of city boundaries is available at the County of Santa Clara Planning Department.

FIGURE 4

Urban Service Area Boundaries

Source: Santa Clara County Planning

FUTURE NONPOINT SOURCES OF NITRATE

Based on past and present trends, one would expect nitrogen-loading due to fertilized agricultural areas to decrease. This reduction would be attributed to the conversion of agricultural land to residential land as well as more prudent fertilization practices. On the contrary, one would expect nitrogen contributions due to septic tank areas to increase as a result of the conversion of agricultural land to residential land.

According to the Santa Clara County Department of Planning and Development, the County's general plan for future growth in the study area is that of slow growth. In other words, the County's future plan will be essentially the same as the current County plan which accommodates additional housings on the existing legal lots. Any future growth, should it occur, would be limited to the maximum increase of 50-75 dwelling units per year. Based on the above maximum allowable growth rate and the average wastewater flow rate of 70 gallons per day (gpd), a calculation was made to estimate the projected range of average nitrogen loading by septic tanks for the year 2000. The average estimated loading is equal to 132,000 lbs per year. Comparing this estimate to past and present estimates, a drastic increase in nitrogen loading due to septic tanks is not anticipated in the next decade.

Since growth will be limited, one would also expect that currently designated agricultural areas will remain agricultural. Therefore, the decreasing trend of nitrogen loading due to fertilized agricultural lands is expected to stabilize. However, the District believes that the decreasing trend of nitrogen loading due to fertilized agricultural areas will continue over the next decade. The District believes that over the next several years, more farmers will become educated in more prudent fertilizer practices.

Also, changes in pertinent government regulations may also contribute to further reduction in nitrogen loadings in the study area. For example, currently, as well as in the future, the San Martin area may decrease its nitrogen loading, due to the 5-acre rural residential parcel rule. Figures 5 and 6 show land use in the basin and in the San Martin area, respectively. Note that all areas shown as RR-5a (rural residential, 5-acre minimum) on Figure 6, were classified as A1-2.5 (2.5 acre minimum) prior to 1983.

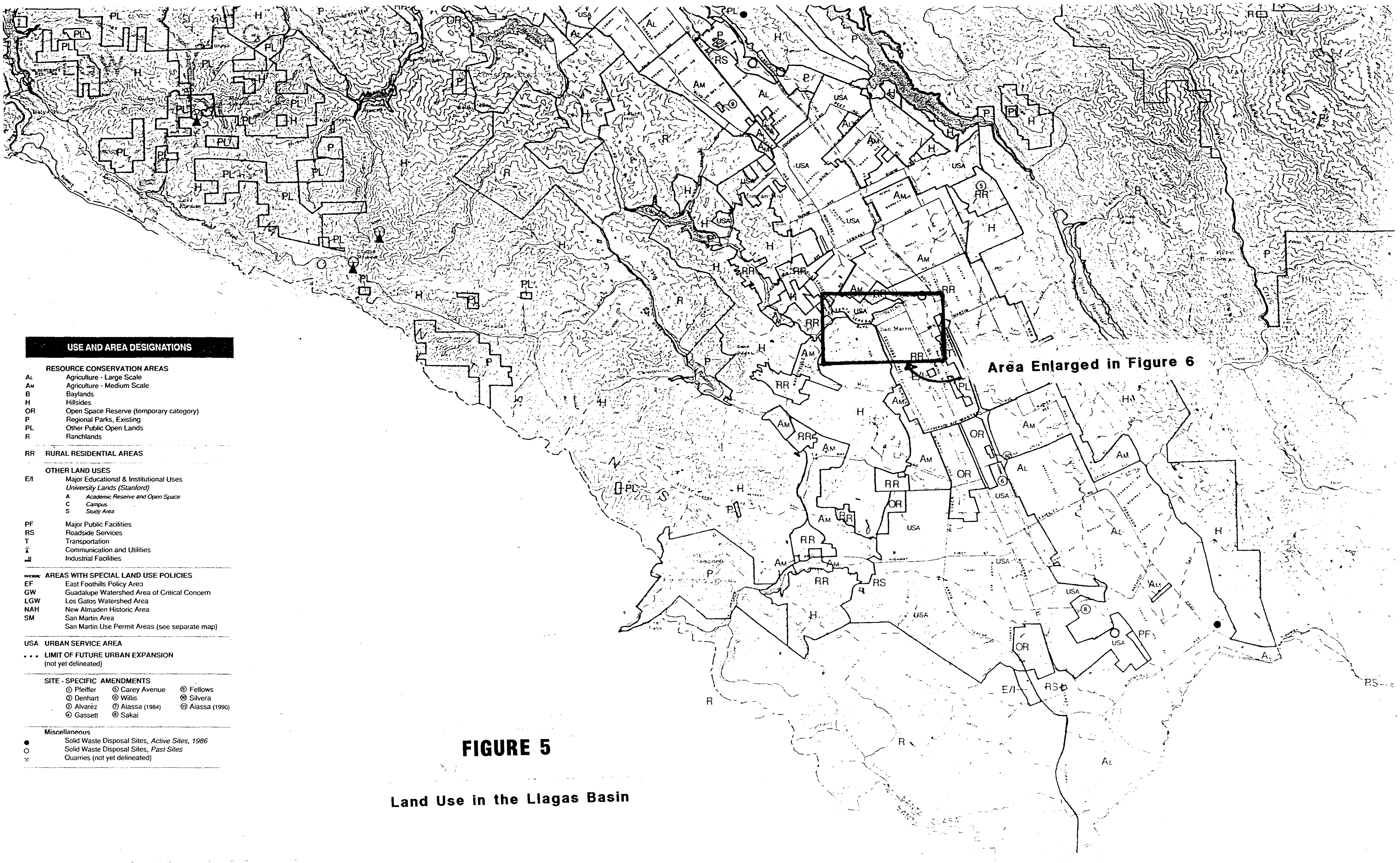

Area Enlarged in Figure 6
USE AND AREA DESIGNATIONS
RESOURCE CONSERVATION AREAS
AL Agriculture - Large Scale
AM Agriculture - Medium Scale
B Baylands
H Hillsides
OR Open Space Reserve (temporary category)
P Regional Parks, Existing
PL Other Public Open Lands
R Ranchlands
RR RURAL RESIDENTIAL AREAS
OTHER LAND USES
E/I Major Educational & Institutional Uses
University Lands (Stanford)
A Academic Reserve and Open Space
C Campus
S Study Area
PF Major Public Facilities
RS Roadside Services
T Transportation
Communication and Utilities
Industrial Facilities
AREAS WITH SPECIAL LAND USE POLICIES
EF East Foothills Policy Area
GW Guadalupe Watershed Area of Critical Concern
LGW Los Gatos Watershed Area
NAH New Almaden Historic Area
SM San Martin Area
San Martin Use Permit Areas (see separate map)
USA URBAN SERVICE AREA
• • • LIMIT OF FUTURE URBAN EXPANSION (not yet delineated)
SITE - SPECIFIC AMENDMENTS
① Pfeiffer ⑤ Carey Avenue ⑨ Fellows
② Denhart ⑥ Willis ⑩ Silvera
③ Alvaréz ⑦ Aiassa (1984) ⑪ Aiassa (1990)
④ Gassett ⑧ Sakai
Miscellaneous
● Solid Waste Disposal Sites, Active Sites, 1986
○ Solid Waste Disposal Sites, Past Sites
⚒ Quarries (not yet delineated)
San Martin
USA
AM
AL
RR
OR
H
R
P
PL
PF
RS
E/I

FIGURE 5

Land Use in the Llagas Basin

Source: Santa Clara County Planning

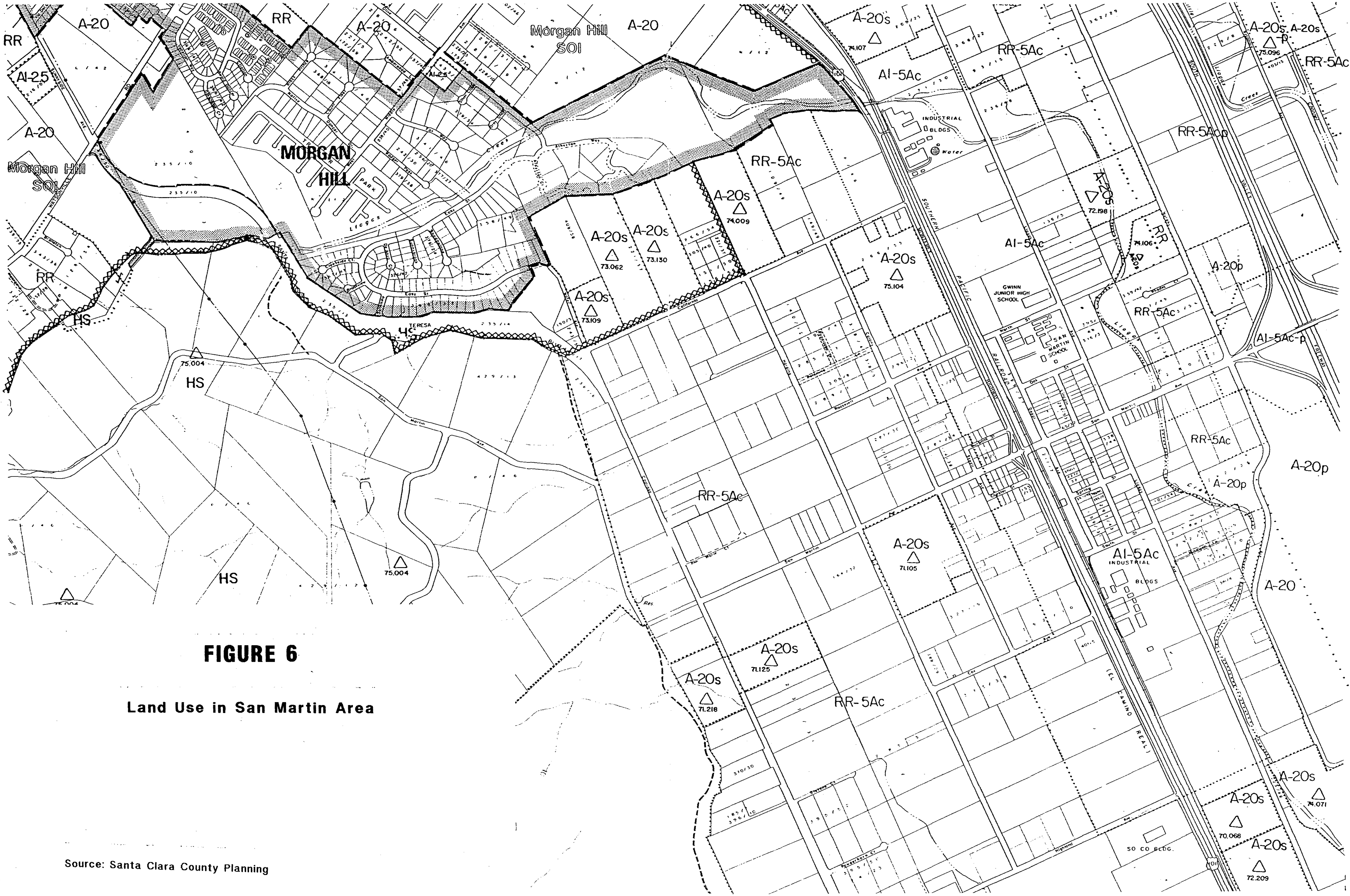


FIGURE 6

Land Use in San Martin Area

Source: Santa Clara County Planning

V. POINT SOURCES OF NITRATE

For purposes of this section, point source is defined as a source which is traceable to a specific point or location such as a percolation pond, a manure pile, or a discharge pipe. Point sources are sometimes permitted and regulated under the jurisdiction of the Regional Water Quality Control Boards. Typically, point sources are more readily identifiable and more controllable than nonpoint sources. It is important to identify point sources because they may be significant contributors to groundwater degradation in Llagas Basin.

Studies completed in various areas of California and in the United States have identified which types of point sources have the greatest potential for causing nitrate pollution. Many types of sources that have been identified in other studies are also known to exist or to have existed in Llagas Basin. Some of these sources are briefly described below. Also, calculations to estimate potential nitrogen loadings from each point source are made.

Similar to nonpoint sources of nitrate, it is difficult to accurately determine the exact amount of nitrate that would leach to groundwater from each source mainly because the processes of nitrogen transformation, including volatilization, denitrification, and assimilation, are not well understood (Ralston et al, 1994). However, reasonable estimates of maximum potential nitrate loading from each source can be made using various empirical and theoretical scientific information, as well as professional judgement. Standard practice is to calculate the potential nitrogen loading (expressed in terms of total nitrogen) from each source and to use those values as the maximum amount of nitrate that could leach to groundwater from each identified source. This correlation is justified by the fact that nitrogen is present predominantly as the nitrate ion, and as nitrite or ammonium only to a minor degree.

Calculations to estimate potential nitrogen loadings are based on data and information from the CCRWQCB, the County Department of Agriculture, the Santa Clara County Department of Planning and Development, DWR, CDFA, census reports, and information from experts and technical literature. In particular, sample calculations and other pertinent data presented in the Guidance Manual by Rolston et al. at UC Davis are used wherever appropriate and/or applicable.

Most point source facilities identified in the study area are regulated by CCRWQCB for proper management of wastes generated. These include animal confinement operation facilities (i.e. dairies, cattle feed lots, egg farms), food packing operations and wineries, cogeneration facilities, sewage treatment facilities, and mushroom farms and composting operations. The requirements as set forth by the CCRWQCB are recognized in this report.

A summary of estimated potential nitrogen loading from each source is shown in Table 6; sample calculations are provided in Appendix B. The following paragraphs present the District's basis for using the values found in the sample calculations.

DAIRIES

Dairies can be a significant source of nitrate contamination, especially if the facility has a high population density of animals and the animal wastes, manure in particular, are not handled properly. In the study area, nitrogen loading from dairies appears to be controlled.

Nitrogen loadings from dairies are controlled under the CCRWQCB's Water Quality Control Plan (Basin Plan). Currently, only dairies with 700 head or more pregnant heifers and dry mature cows in the study area are required to have a permit as a point source under the National Pollution Discharge Elimination System (NPDES) for waste discharge. However, the CCRWQCB may require discharge permits from any discharger, i.e. dairy, regardless of size. Specific CCRWQCB's policies pertaining to animal confinement operations include a requirement that manure be regularly removed by scraping corrals and barns, storing it temporarily in a bermed manure holding area, hauling it off-site and properly applying or disposing of it so as not to adversely affect water quality.

According to the census of Manufacturers data, the number of dairy establishments in Santa Clara County began decreasing steadily in 1963 (23 dairies), then stayed essentially constant throughout the 1980s (14 dairies), and again decreased slightly by 1990 (10 dairies). According to CCRWQCB's record of permitted waste dischargers, in 1990, four dairies were identified in the study area.

The four existing dairies are required under Waste Discharge Requirements (WDR) issued by the CCRWQCB to manage their wastes: manure on the floors of corrals and barns are periodically scraped, temporarily stored at the manure storage area, and hauled off-site when dry; and washwater, stormwater runoff, and other wastewaters are disposed of at the retention ponds, disposal fields, and/or percolation reservoir under the state regulations.

In addition, they may be required to comply with a site specific monitoring and reporting program as well as the "Standard Provisions and Reporting Requirements for Waste Discharge Requirements: dated January, 1984" (Standard Provisions). The site specific program involves (1) installation of monitoring wells up and downgradient of the disposal area and (2) sampling and analyses of various pertinent chemicals including nitrate. According to the Standard Provisions, if additional data through monitoring or investigation indicates that compliance with the WDR is not adequately protecting groundwater, the CCRWQCB will review and revise the WDR as appropriate in order to ensure the protection of water quality.

Based on the management practices set forth in the WDR, the greatest threat of nitrogen loading appears to be from the disposal ponds which contain washwater, stormwater runoff, and other wastewaters. Therefore, the calculations in this report focus on nitrogen contributions from the disposal ponds.

Based on data received from the CCRWQCB, potential nitrogen loading calculations for the four dairies in the study area could only be made for 1990. Although actual data is unavailable for the 1970s and 1980s, one would expect the contribution from dairies to be higher during those decades. More dairies existed and such controlled management of wastes was not practiced.

Table 4 shows the flow rates of wastewater entering the lagoon (pond) system that is commonly used for treatment and/or disposal by dairies. A concentration of nitrogen equal to 80 mg/l, which is typical for dairy wastewater stream (Nemerow and Dasgupa, 1991) was used. Also, based on information in the Guidance Manual by Rolston et al. nitrogen loss due to volatilization from wastewater containing animal wastes is 70 to 80 percent in the pond system. Therefore, a reasonable estimate of the total percentage of nitrogen loading that could potentially leach to groundwater through the pond bottoms is equal to 20 to 30 percent.

TABLE 4
Wastewater Flow Rates and Estimated Potential Nitrogen Loadings to Groundwater by Dairies

	Dairy A (San Martin)	Dairy B (Gilroy)	Dairy C (Gilroy)	Dairy D (Gilroy)
Daily Flow Rate (gallons/day)	3,400	34,000	27,500	30,000
Nitrogen Loadings (thousands pounds/year)	0.16-0.25	1.65-2.48	1.34-2.01	1.46-2.19

As indicated previously, the calculated amounts above do not represent exact nitrogen loadings that would leach to groundwater. However, they do represent estimated potential nitrogen loadings that reasonably demonstrate that the total nitrogen loadings from the four dairies, approximately 4,400 -6,900 pounds per year, are relatively small compared to those from septic tank areas and fertilized crop lands.

CATTLE FEED LOTS

Because of the high population density of animals and large quantities of manure generated, cattle feed lots can be significant sources of nitrate contamination. However, similar to dairies, the CCRWQCB has set forth management requirements via the CCRWQCB's Water Quality Control Plan (Basin Plan).

Currently, feed lots with 1,000 or more cattle (large-size) are regulated under the CCRWQCB's Water Quality Control Plan (Basin Plan) and are required to have a permit as a point source under the NPDES for waste discharge. Although the CCRWQCB's focus is on large-size feed lots, the CCRWQCB may also require discharge permits from any discharger, i.e. feed lot, regardless of size. Based on conversations with the CCRWQCB (personal communication, 1994), no permits have been issued for feed lots—large or small.

Some of the specific requirements under the WDR for animal confinement operations are (1) to have adequate surface drainage to prevent continuous accumulation of surface waters in feed lots, (2) to be protected from overflow to stream channels during flood, and (3) to manage manure storage areas to minimize percolation of water into underlying soils.

Additionally, they may be required to comply with a site specific monitoring and reporting program as well as the Standard Provisions dated January, 1984. The site specific program typically involves monitoring of runoff from feed lots that includes periodic sampling of total organic nitrogen. According to the Standard Provisions, if additional data through monitoring or investigation indicates that compliance with the WDR is not adequately protecting groundwater, the CCRWQCB will review and revise the WDR as appropriate in order to ensure the protection of water quality.

Historically, feed lots with cattle populations in excess of 2,000 animals have existed in Llagas Basin. However, discussions with the county farm advisor, the county department of agriculture statisticians, and local farmers of the study area (personal communication, 1994) indicate that there have not been any large-size beef cattle feed lots for at least the last two decades. Beef cattle in the study area are raised in pasture and range land in addition to small-size feed lots where up to 150 to 200 beef cattle are concentrated. Once beef cattle reach approximately 600 pounds in weight, they are shipped out to slaughter houses in other counties. Information on the number and actual size of such feed lots is not available.

It is especially difficult to estimate potential nitrogen loadings from animal sources, such as feed lots, compared to other point sources because nitrogen losses due to volatilization and/or denitrification are unknown in most situations (Rolston et al., 1994). However, as suggested in the Guidance Manual by Rolston et al., first, the maximum nitrogen excreted by the beef cattle population of the study area was estimated. This estimated amount should provide an initial measure to determine whether beef cattle manure is a potentially significant source of nitrate contamination or not.

Calculations presented in Appendix B to estimate the maximum nitrogen in manure are based on the following information: (1) nitrogen contents of beef cattle manure are 124 kgs per 1000 kg live weight of cattle and typical live weight is 360 kgs (Rolston et al., 1994); and (2) the beef cattle populations of the study area are estimated to be between 20,000 and 50,000. The lower value (20,000) is based on the data provided by the 1987 Census of Agriculture and the upper value (50,000) is based on the 1990 County Crop Report and discussions with the statistician who compiled the Crop Report (personal communication, 1994). Since the CCRWQCB has not issued any permits for large-size feed lots, their primary focus, it can be assumed that the 20,000 to 50,000 cattle are either raised in pasture and range land, or are divided amongst several small-size feed lots.

Results of the calculations reported an estimated maximum nitrogen loading equal to 1,080,000 to 2,691,000 lbs per year. This clearly demonstrates that beef cattle manure can be a significant source of nitrate contamination.

Following the procedures established in the Guidance Manual by Rolston et al., calculations were then made to estimate (1) maximum potential nitrogen loadings from beef cattle manure after nitrogen losses due to volatilization, denitrification and plant uptake, and (2) potential nitrogen loadings as a result of applying manure to crop lands as fertilizer.

Based on discussions with the county farm advisor (personal communication, 1994), a maximum of 5 percent of beef cattle manure generated is used as crop fertilizer in the study area; this percentage is reflected in the calculations. Also, reflected in the calculations is (1) a 50 percent nitrogen loss in the manure due to volatilization before land application as fertilizer; and (2) a 10 to 20 percent loss due to denitrification and a 50 percent nitrogen loss due to crop uptake (Rolston et al., 1994). Results show that the maximum potential nitrogen loading from beef cattle manure is 162,000 to 538,000 pounds. The low end represents an estimated cattle population of 20,000; the high end represents an estimated cattle population of 50,000. Potential nitrogen loading due to applying manure to crop lands is approximately 8,100 to 26,900 pounds.

Data in the County Crop Reports and the Census of Agriculture report were reviewed for previous years. The estimated ranges of beef cattle populations were approximately the same as the estimate for 1990. It could be assumed that contributions from cattle feed lots has remained relatively consistent over the last few decades. However, contributions from cattle feed lots was most likely more significant in the past due to the lack of waste management.

Beef cattle manure that is not collected for fertilizer use remains in pasture and range land, and/or small scale feed lots where up to 150 to 200 animals are concentrated in a relatively small area. Active feed lots tend to have an environment unfavorable for nitrification and pollutant (i.e. nitrate) movement because of the highly compacted soil from the animal traffic. This condition, however, would increase the potential for surface water contamination from runoff (Miller, 1980). Therefore, it is important to keep the feed lots dry by diverting runoff water from manure areas. On the other hand, abandoned feed lots may provide a large flux of nitrate to groundwater than active lots because the soil beneath abandoned feed lots is looser and more readily allows nitrogen to be converted to nitrate and transported with percolating water.

EGG FARMS

Egg farms, like cattle feed lots, have a high concentration of animals per area. Egg farms produce large quantities of chicken manure which has high concentrations of nitrogen. Because egg farms have a high concentration of animals and produce large quantities of relatively high nitrogen content, they potentially are significant point sources of nitrate contamination.

Similar to dairies and feed lots, large size egg farms are required to obtain a permit for waste discharge from the CCRWQCB. Also, the CCRWQCB may require discharge permits from any egg farm regardless of their size. Under the WDR, the CCRWQCB regulates waste management practices of egg farms with specific policies pertaining to animal confinement operations. In addition, they may be required to comply with a site specific monitoring and reporting program as well as the Standard Provisions dated January, 1984. According to the Standard Provisions, if additional data through monitoring or investigation indicates that compliance with the WDR is not adequately protecting groundwater, the CCRWQCB will review and revise the WDR as appropriate in order to ensure the protection of water quality.

The number of egg farms in the study area has steadily decreased since the 1960s when there were up to ten egg farms. Presently, it is reported that four egg farms exist in the study area (Ferrari, 1994). One egg farm in Gilroy handles approximately 230,000 chickens which account for more than two-thirds of the total chicken population in the entire Santa Clara County—350,000 heads according to the 1992 County Crop Report.

Nitrogen loading data for all egg farms of the past and present was unavailable. However, data was obtained for the above-mentioned egg farm in Gilroy. Using this information as well as information from the Guidance Manual by Rolston et al., calculations were performed. The following information was provided in the Guidance Manual and used in the calculations: (1) nitrogen contents of chicken manure equals 307 kgs per 1000 kg live weight of chickens; typical live weight is 1.8 kgs; (2) all the manure generated is assumed to be stored in an open lot and no other handling of manure wastes is carried out; and (3) 40 to 60 percent of nitrogen in manure is initially lost due to volatilization and an additional 10 to 20 percent is lost due to denitrification in an open lot. As seen in Table 6, approximately 90,000 to 151,000 lbs per year of nitrogen potentially reach groundwater underneath the open lot of the Gilroy egg farm. This range represents the maximum possible nitrogen loading rate; the calculation is based on the assumption that no adequate management of manure generated, other than storing in an open lot, is carried out. The calculated amount of nitrogen loadings clearly demonstrates that egg farms can become a significant source of nitrate without proper management of chicken manure.

According to the operation manager (personal communication, 1994), the Gilroy egg farm has been scraping manure on a daily basis from the lay houses; storing it in an area with a concrete floor, and shipping it off site for disposal usually within 24 hours. Therefore, the actual amount of nitrogen loading from this particular egg farm, provided frequent scraping of and proper disposal of manure occur, would be far less than the amount calculated above. In general, the more appropriately waste is managed on egg farms, the closer the potential nitrogen loading is to zero.

FOOD PACKING OPERATIONS

In the food packing industry, the greatest threat of nitrogen loading appears to be from the disposal ponds which contain wastewater. Calculations in this report focus on potential nitrogen contributions from these ponds.

According to the census of Manufacturers data, the number of food packing facilities in Santa Clara County decreased from 1967 to 1987, then stayed essentially constant from 1987 to 1990. In 1967, 1984, 1987, and 1990, 18, 11, 8, and 8 food packing facilities existed in the County, respectively. In 1990, three food packing facilities existed in the study area.

The three existing food packing facilities are required under Waste Discharge Requirements issued by the CCRWQCB to properly manage wastes generated. For example, food process wastewater is permitted to be discharged only to the designated disposal ponds and/or septic tank/leach field system. Also, they are required to maintain the discharge of wastes so that overflow, seepage, or bypass of wastewater discharge onto adjacent properties, or into drainageways, storm sewers, or Llagas Creek does not occur.

In addition, they may be required to comply with a site specific monitoring and reporting program as well as the Standard Provisions, dated January, 1984. The site specific program involves (1) installation of monitoring wells up and downgradient of the disposal area and (2) sampling and analyses of various pertinent chemicals including nitrate. According to the Standard Provisions, if additional data through monitoring or investigation indicates that compliance with the WDR is not adequately protecting groundwater, the CCRWQCB will review and revise the WDR as appropriate in order to ensure the protection of water quality.

Based on data received from the CCRWQCB, potential nitrogen loading calculations could only be made for 1990. Although actual data is unavailable for previous years, one would expect the contribution from food packing facilities to be higher during those decades; more facilities existed, and such controlled management of wastes was not practiced.

Table 5 shows the flow rates of wastewater, nitrogen concentrations and estimated potential nitrogen loadings from the three food packing facilities in the study area. It is assumed that 20 to 30 percent of the nitrogen generated potentially reaches groundwater through the disposal pond bottoms (Rolston et al., 1994).

TABLE 5
Wastewater Flow Rates, Nitrogen Concentrations, and Estimated Potential Nitrogen Loadings to Groundwater by Food Packing Operations

	Facility A (San Martin)	Facility B (Gilroy)	Facility C (Gilroy)
Daily Flow Rates (gallons/day)	320,000	961,000	233,000
Nitrogen Concentrations (mg/l)	8	1.51	7.3
Nitrogen Loadings (thousands pounds/year)	1.6-2.3	0.9-1.3	1.0-1.6

The estimate of total potential nitrogen loadings from the three food processing facilities is approximately 3,500 - 5,200 pounds per year. As seen in Table 6, food packing facilities contribute a relatively small amount of nitrogen compared to septic tanks and commercial crop fertilization.

WINERIES

Wineries can be potential sources of nitrate contamination due to the relatively high nitrogen concentrations in process wastewater.

Currently, wineries are required to have either permits for waste discharge, or a waiver for waste discharge requirements from the CCRWQCB, which includes implementing best management practices for waste generated. Under the WDR, they may be required to comply with a site specific monitoring and reporting program as well as all items of the Standard Provisions, dated January, 1984. According to the Standard Provisions, if additional data through monitoring or investigation indicates that compliance with the WDR is not adequately protecting groundwater, the CCRWQCB will review and revise the WDR as appropriate in order to ensure the protection of water quality.

According to the census of Manufacturers data, the number of wineries in Santa Clara County with 20 or more employees decreased from 1967 to 1990. In 1967, 1984, and 1990, 4, 3, and 2 wineries existed in the County, respectively. Nitrogen loading contributions from this type of source most likely experienced the same trend.

Nitrogen loading data for all wineries of the past and present was unavailable. However, the 1981 study by Brown and Caldwell calculated potential nitrogen loading from a winery in San Martin based on an estimated flow of 1 million gallons per year and an estimated nitrogen concentration of 30 mg/l in wastewater. The calculated amount of 250 pounds per year of potential nitrogen loading is relatively small compared to those by other potentially large contributors of nitrate contamination in the study area.

COGENERATION FACILITIES

Cogeneration facilities convert agricultural and food packing waste products into electrical energy (typically through steam generation). The greatest threat of nitrogen loading from cogeneration facilities appears to be from disposal ponds which contain wastewater.

Based on information from the CCRWQCB, only one cogeneration facility has existed in the study area, in Gilroy. This facility is required under Waste Discharge Requirements issued by the CCRWQCB to properly manage wastes generated. This facility, for example, is permitted to discharge its wastes only to the designated wastewater disposal areas.

In addition, this facility may be required to comply with a site specific monitoring and reporting program as well as the Standard Provisions dated January, 1984. The site specific monitoring program involves (1) installation of monitoring wells up and downgradient of the disposal area and (2) sampling and analyses of various pertinent chemicals including nitrate. According to the Standard Provisions, if additional data through monitoring or investigation indicates that compliance with the WDR is not adequately protecting groundwater, the CCRWQCB will review and revise the WDR as appropriate in order to ensure the protection of water quality.

It generates approximately 100,000 gallons of wastewater per day throughout the year. These wastes consist primarily of cooling tower and boiler blowdowns and neutralized demineralizer regenerant wastewater which contain approximately 36.4 mg/l of nitrate as nitrogen. As with food packing facilities, cogeneration facilities often dispose of their wastewater in evaporation/percolation ponds. Based on the above flow rate and nitrogen concentration information, and the leaching percentage of 20 to 30 percent (Rolston et al., 1994), potential nitrogen loading from the cogeneration facility in Gilroy was estimated to be approximately 2,200 -3,300 pounds per year. This is a relatively small amount compared to those from septic tanks and crop fertilization.

SEWAGE TREATMENT FACILITIES

Sewage treatment facilities concentrate and treat sewage and wastewater from urban areas that are not served by on-site sewage treatment systems. Because human waste contains high concentrations of nitrogen, sewage treatment facility wastewater often contains significant concentrations of nitrate.

A sewage treatment facility in the study area is required under Waste Discharge Requirements issued by the CCRWQCB to properly manage wastes generated. This facility is prohibited from discharging its wastes to areas other than the designated domestic wastewater disposal ponds. Also, nitrate concentrations in the groundwater affected by the disposal area are not allowed to exceed 10 mg/l by the waste discharge.

This facility is prohibited from discharging its wastes to areas other than the designated domestic disposal ponds. As required to comply with the Monitoring and Reporting Program No. 92-20, this facility has shallow monitoring wells installed within and in the immediate vicinity of the disposal ponds. Periodic samplings are conducted in the existing wells to assess impact of the discharge to groundwater.

During 1993, a sewage treatment facility that currently serves Llagas Basin had discharged an average daily flow of 5.0 million gallons of treated wastewater with a nitrate concentration of 0.67 mg/l. Wastewater effluent at this sewage treatment facility is ultimately discharged to 197 acres of evaporation/percolation ponds. It is assumed that 20 to 30 percent of the nitrogen generated potentially reaches groundwater through the bottoms of the disposal ponds (Rolston et al., 1994). Based on the flow rate and nitrogen concentration data above, it was estimated that potential nitrogen loading is 2,100 - 3,100 pounds per year, which is relatively small compared to those from septic tanks and crop fertilization.

Specific daily flow rates were unavailable for previous years. However, by reviewing population information, reasonable conclusions could be drawn regarding past nitrogen loading trends. Based on conversations with the Santa Clara County Department of Planning and Development (personal communication, 1994), the urban areas of Morgan Hill and Gilroy had a combined population of 38,701 and 55,415 in 1980 and 1990, respectively. Both cities were unincorporated in 1970; therefore, population information is unavailable. Based on this information, it is reasonable to assume that potential nitrogen loadings from sewage treatment plants have increased since 1970, in proportion to the increase in population.

SEWAGE DISPOSAL PITS

Sewage disposal pits were historically used to dispose of domestic and/or commercial sewage, usually septic tank effluent, for housing facilities which had populations too large to utilize conventional on-site disposal systems. They are no longer in use today. Because the pits were used to discharge human waste which contains nitrogen, they were point sources of nitrate contamination.

Information on the number of sewage disposal pits that existed in the study area is unavailable. However, we are aware of one sewage disposal pit that was in operation at the 250-300 man farm labor service camp, located about two miles east of Morgan Hill, during the 1950s and the 1960s (DWR, 1963). This pit, consisting of three 36-inch diameter sewage sumps in depth from 70-78 feet, received septic tank effluent.

Calculations were made to estimate potential nitrogen loadings from sewage disposal pits. For the calculations, it is assumed that the average nitrogen concentration of septic tank effluent is 40 mg/l and the average wastewater flow rate is 70 gpd (Metcalf and Eddy, 1991). Also, the leaching fraction is assumed to be within a relatively small range of 20 to 30 percent because construction of sewage disposal pits were limited to the areas where surface permeability of soil is sufficiently low (DWR, 1963).

The potential nitrogen loading (470 to 700 lbs per year) calculated from this sewage disposal pit is relatively small compared to those from septic tanks and fertilized agricultural lands. Also, it can be reasonably assumed that the old sewage disposal pit sites do not present a threat to groundwater nor are on-going sources of nitrate contamination for the following two reasons: (1) as shown, the relative size of potential nitrogen loading from a large size sewage disposal pit was considerably small; and (2) since these pits are no longer in use, practically all of the residual nitrogen in the soil decomposed over the years to nitrate and already reached groundwater, or was lost to the air via further denitrification and volatilization.

MUSHROOM FARMS AND COMPOSTING OPERATIONS

Mushroom farms are potential nitrate point sources because they use large quantities of high nitrogen materials (compost) as a medium for growing mushrooms. Typically, compost is produced on site from bulk animal manure (such as horse manure) and other agricultural wastes. During composting operations, usually carried out on concrete composting slabs, water is added to assist the composting process and is constantly leaching through compost piles (CCRWQCB, 1989). Compost leachate and irrigation/wastewater are high in nitrogen which presents nitrate contamination problems for groundwater, if not properly managed.

Mushroom farm operations are currently regulated under the CCRWQCB's Basin Plan and thus are required to have a permit for their waste discharge. The CCRWQCB's policies regarding mushroom farm operations specifically prohibit discharge of compost leachates, washwater, or contaminated stormwater to areas other than the designated and approved areas for treatment, storage, and disposal, such as lined oxidation/evaporation ponds. Additionally, they may be required to comply with a site specific monitoring and reporting program as well as the Standard Provisions dated January, 1984. The site specific program involves collection of representative grab samples of effluent within the lined pond and analysis for dissolved oxygen. According to the Standard Provisions, if additional data through monitoring or investigation indicates that compliance with the WDR is not adequately protecting groundwater, the CCRWQCB will review and revise the WDR as appropriate in order to ensure the protection of water quality.

Discussions with a mushroom operator in the study area indicated that in the 1950s and 1960s, eight mushroom farms existed in the study area (personal communication, 1994). From the 1970s to the present, six mushroom farms existed. Each of these mushroom farms produces compost through on site composting operations and there is no outside independent composting facility in the study area.

Based on data from the CCRWQCB, potential nitrogen loading calculations for only one mushroom farm could be performed for 1990. Although specific data is unavailable for the 1950s through the 1980s, one would expect that nitrogen loadings from mushroom farms and composting facilities to be higher in the past, especially in the 1950s and 1960s when more mushroom farms existed and controlled management of wastes was not practiced.

The mushroom farm generates an average flow of 3,000 gallons per day of wastewater. It is assumed that (1) the nitrogen concentration is 85 mg/l which is based on the characteristics of strong domestic wastewater, and (2) 20 to 30 percent of the nitrogen produced potentially reaches groundwater through the oxidation/evaporation ponds bottoms (Rolston et al., 1994). Based on the flow rate and nitrogen concentration, potential nitrogen loadings are estimated to be approximately 960 to 1380 pounds per year. The potential nitrogen loadings calculated above are relatively small compared to those from septic tanks and fertilized agricultural lands.

GREENHOUSE OPERATIONS

Greenhouses typically concentrate large amounts of agricultural activities into a small area. The greenhouses of Santa Clara County, grow primarily nursery crops (e.g. bedding plants and ornamental trees) and cut flowers (e.g. carnations and roses), and these two represent the two biggest cash crops in the County.

Greenhouse activities often operate year round and therefore have more fertilizer applications than non-greenhouse agricultural practices. Because greenhouses use nitrogen-based fertilizers to increase crop production they can be significant point sources of nitrate contamination.

According to the County Crop Reports for 1960, 1970, 1980, and 1990, the total acreage of greenhouse operations in the study area was approximately 328, 480, 807, and 602 acres, respectively. Based on this information, there appears to have been an increase in greenhouse operations from 1960 to 1980, and then a decrease from 1980 to the present. It can be assumed that nitrogen loading contributions from this type of source experienced the same trend.

A benchmark calculation was made to estimate potential nitrogen loadings from greenhouse operations in the study area for 1990. For these calculations, a leaching percentage equal to 30 percent, the same as that used for fertilized agricultural land calculations, was used. According to discussions with the local greenhouse operators (personal communication, 1994) and information provided in the Survey of Fertilizer Use In California, the nitrogen fertilizer application rate is estimated to be between 200 and 1,000 lbs per acre a year. Also, the typical nitrogen content in nitrogen fertilizer is assumed to be 30 percent, the same as that used for fertilized agricultural land.

Using the information above, the estimated potential nitrogen loadings due to greenhouse operations in the study area is approximately 10,800 - 54,000 lbs per acre a year. It appears that greenhouse operations are one of the significant point sources of nitrate contamination.

TABLE 6
Summary of Estimated Potential Nitrogen Loadings to Groundwater

		Total Potential Nitrogen Loadings[1],[2] Thousands Pounds				
		Year				
		1967	1970	1978	1980	1990
Nonpoint Source	Agricultural Lands Fertilized by Commercial N-Fertilizer	276		250		227
	Agricultural Lands Fertilized by Beef Cattle Manure					8.1-26.9
	Septic Tank Areas		44-123		49-140	53-151
	Rainwater					14
Point Source	Dairies					4.6-6.9
	Cattle Feed Lots[3]					162-538[3]
	Egg Farm[4]					90-151[4]
	Food Packaging Operations					3.5-5.2
	Cogeneration Facility					2.2-3.3
	Sewage Treatment Facilities					2.1-3.1
	Sewage Disposal Pits					0.47-0.70
	Mushroom Farms/ Composting Operation					0.16-0.23
	Greenhouse Operations					11-54

[1] Amounts of nitrogen available for potential leaching to groundwater after nitrogen losses due to volatilization, denitrification, and/or plant uptake.

[2] For the study area.

[3] Assumed no proper waste management.

[4] Assumed all the manure is stored in an open lot with no proper waste management.

PAST POINT SOURCES OF NITRATE CONTAMINATION

Because vertical migration from a point source to groundwater may take a considerable amount of time, contamination from current sources may not yet have reached groundwater. Therefore, it is important to examine groundwater quality in the vicinity of both past as well as present point sources.

Like today, Llagas Basin has historically been an agricultural area with the commercial and residential centers of Morgan Hill, San Martin, and Gilroy located along Old Monterey Highway. As shown in Figures 3 and 4, while land use in the basin has remained predominantly agricultural, residential development of the area has rapidly progressed, displacing agricultural uses.

Though the number of point sources has not significantly changed, the types of point sources have. Dairies and cattle feed lots were once common in the basin, but due to a federally sponsored buy out in the early 1980s, few dairies remain today; and there have not been large scale cattle feed lots for at least the last two decades. Conversely, greenhouse operations were not as common in the past, but are relatively ubiquitous today.

Many point sources of nitrate have been identified to have historically existed in Llagas Basin. Some source types were found to have been scattered throughout the basin (cattle feed lots, dairies, greenhouse operations, mushroom farms, sewage disposal sumps, etc.) while other sources were clustered around commercial and industrial centers (packing operations, sewage treatment facilities, etc.).

In order to determine what types of past point sources existed in Llagas Basin, historical aerial photographs and maps were studied, groundwater quality reports that listed potential historical point sources were reviewed, and oral interviews were completed. This study did not attempt to identify every historical point source that existed, but did attempt to identify all of the potential nitrate source types that have existed in the basin.

PRESENT POINT SOURCES OF NITRATE CONTAMINATION

As discussed above, nitrate contamination from point sources is currently occurring in Llagas Basin. While some of the historical point source types (i.e. dairies) are not as much of a problem as they once were, other point sources continue to contribute to the nitrate problem in the basin. Some of the primary point source types in the basin today include:

- Sewage treatment facilities
- Food packing operations
- Cattle feed lots
- Cogeneration facilities
- Dairies
- Egg farms
- Mushroom farms and Composting operations
- Greenhouse Operations

While some of these sources are found in the vicinity of the commercial and industrial centers (Morgan Hill, Gilroy), most of the sources are found distributed throughout the agricultural areas of the basin. Figure 5 shows the land use in the basin as of 1991.

In order to determine the location of current point sources of nitrate contamination, aerial photographs and maps were studied, groundwater quality reports that listed potential point sources were reviewed, and oral interviews were completed. As with past point sources, this study did not attempt to identify every point source that exists today, but did attempt to identify all of the potential nitrate source types that exist in the basin.

FUTURE POINT SOURCES OF NITRATE CONTAMINATION

As land use in the basin changes, types of point sources of nitrate contamination will change. Increased urbanization of the area would result in increased sanitary waste water discharge to the basin and much of this increase would probably go to the sewage treatment facility. If nitrogen is not removed from the sewage treatment plant effluent, increasing nitrate concentrations in the groundwater may be expected. Conversely, increased urbanization would probably result in the decrease of agricultural activities in the area. Depending on the type of agricultural activities and the density of residential areas, the loading may increase or decrease. However, according to Santa Clara County Office of Planning and Development, land use changes will most likely be insignificant, at least for the next decade.

VI. CONCLUSIONS

Due to the nature, extent, and number of potential nitrate sources in Llagas Basin, it is difficult to determine the exact amount of nitrogen loading contributed by each particular source. Detectable concentrations of nitrate discovered in a well today may be from a single source, or from a combination of sources. Past nitrate management practices or lack of them may still be affecting the groundwater quality in the basin because transport and transformation of nitrogenous compounds from the ground surface to groundwater may take months to years depending on local subsurface conditions.

Several types of nitrate contamination sources were identified in this portion of the study. Some of the major sources include: septic tank areas, commercial and manure fertilized agricultural areas, other fertilized areas, rainwater, other natural nonpoint sources, dairies, cattle feed lots, sewage treatment facilities, food packing facilities, wineries, greenhouse operations, cogeneration facilities, mushroom farms and composting operations, egg farms, and sewage disposal pits.

In order to assess and compare the relative contribution of each particular source, calculations were made to estimate potential nitrogen loadings based on published literature and personal communications. Table 6 shows the summary of estimated nitrogen loadings to groundwater from each identified source. The results indicate that fertilized agricultural lands and septic tank areas have been the two major sources of nitrate contamination; feed lots and egg farms can be significant point sources if proper waste management is not carried out; and greenhouse operations appear to be a potentially significant point source.

Future land use in the area has the potential to affect nitrate loading to Llagas Basin. Depending on the type of agricultural activities and the density of residential areas in the future, the loading may increase or decrease. According to the Santa Clara County Office of Planning and Development, land use changes will most likely be insignificant, at lease for the next decade. Therefore, average nitrate loading rates to the basin are expected to remain relatively constant. If adequate nitrate management practices are not implemented in order to reduce the total nitrogen loading to the basin, nitrate concentrations in the groundwater in the basin can be expected to remain high, continuing to adversely affect the utilization of groundwater as a source of drinking water.

During the next phase of this study, groundwater sample collection points will be chosen. The points will be selected (1) to sample groundwater near identified source areas; (2) to fill in gaps in areal data, and (3) to continue the trend analyses discussed in the completed report "Nitrate Data Review" dated August 1993.

APPENDICES

APPENDIX A - BIBLIOGRAPHY

APPENDIX B - SAMPLE CALCULATIONS OF NITROGEN LOADING

APPENDIX A

BIBLIOGRAPHY

BIBLIOGRAPHY

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APPENDIX B

SAMPLE CALCULATIONS OF NITROGEN LOADING

SAMPLE CALCULATIONS OF NITROGEN LOADING FOR EACH SOURCE

FERTILIZED AGRICULTURAL LANDS

[Potential Nitrogen Loading for Strawberries in 1990]

= [Nitrogen Application Rate] x [Total Fertilized Acreages] x [Leaching Fraction]

[Nitrogen Application Rate for Strawberries in 1990] = 71 lbs/acre/yr
[Total Fertilized Acreages] = 420 acres
[Leaching Fraction] = 30%

[Potential Nitrogen Loading] = (71 lb/acre/yr) x (420 acres) x (0.30)

= 8,946 lbs/yr

SEPTIC TANK AREAS

[Potential Nitrogen Loading in 1990]

= [Number of Residents] x [Daily Nitrogen Loading per Person] x [Leaching Fraction]

[Number of Residents] = [Number of Dwelling Units in Unincorporated Area] x [Average Number of Persons per Dwelling Unit]
= [4,910] x [2.81] = 13,797
[Daily Nitrogen Loading per Person] = 12 to 17 g N/capita/day
[Leaching Fraction] = 40-80%

[Potential Nitrogen Loading in 1990] = (13,797) x (12 to 17 g N/capita/day) x (365 days/year) x (0.0022 lb/g) x (0.4 to 0.8)
$\cong$ 53 to 151 x 10^3 lbs/yr

RAINWATER

1. [Amount of Total Nitrogen in Rainwater] = 1.3 mg/l
   [Average Rainfall per Year] = 20.80 in/yr
   [Area of Llagas Creek Watershed] = 89.47 sq.mi.

   [Maximum Potential Nitrogen Loading]
   = (1.3 mg/l) (28.317 L/ft^3) (1g/1000 mg) (1kg/1,000g) (20.80 in/yr)
   x 1 ft/12 in) (89.47 sq.mi.) (5280^{2}ft^2/1 sq. mi.) (2.20462 lbm/kg)
   = 351 x 10^3 lbm N/yr

2. [Percent Infiltration] = 10 %

   [Maximum Potential Nitrogen Loading]
   = (351 x 10^3 lbm N/yr) (0.10)
   = 35.1 x 10^3 lbm N/yr

3. [Nitrogen Loss due to Crop Uptake] = 50%
   [Nitrogen Loss due to Denitrification] = 10 %

   [Maximum Potential Nitrogen Loading]
   = (35.1 x 10^3 lbm N/yr) (0.40)
   = 14 x 10^3 lbm N/yr

DAIRY A

[Potential Nitrogen Loading]

= [Concentration of Total Nitrogen] x [Daily Flow Rate] x [Leaching Fraction]

[Concentration of Total Nitrogen] = 80 mg/l
[Daily Flow Rate] = 3,400 gallons/day
[Leaching Fraction] = 20 - 30%

[Potential Nitrogen Loading]= (80 mg/l) x (3,400 gallon/day) x (0.20 to 0.30) x (365 days/year) x (3.7854 L/gal) x (1 g/1,000mg) x (0.0022 lb/g)

= 165 to 248 lbs/yr

CATTLE FEED LOTS

1. [Maximum Nitrogen in Beef Cattle Manure] =

[Number of Cattle] x [Nitrogen Generated per Cow per Year] x [Number of Days of Stay in Feed Lot per Year]

[Number of Cattle in 1990] = 20,000 - 50,000
[Annual Nitrogen Generated] = 124 kg N/1000 kg live wt (Typical Live Wt = 360 kg)
[Number of Days of Stay] = 200 days

[Maximum Nitrogen in Beef Cattle Manure] = (20,000 to 50,000 cows) x (124 kg N/1000kg live wt) x (360 kg live wt) x (200/365 yr) x (2.2 lb/kg)

= 1,080 to 2,691 x 10^3 lbs/year

2. Maximum Potential Nitrogen Loading After N Losses due to Volatilization, Denitrification, and Plant Uptake =

[Maximum Potential Nitrogen Loading] x [1 - Nitrogen Loss Fraction]

[Nitrogen Loss Fraction] = 50 % due to volatilization initially + 60 to 70% due to denitrification and plant uptake

[Maximum Potential Nitrogen Loading] = (1,080 to 2,691 x 10^3) x (0.5)

= 540 to 1,346 x 10^3 lb/year

(540 to 1,346 x 10^3 lb/year) x (0.3 to 0.4) = 162 to 538 x 10^3 lbs/year

3. Potential Nitrogen Loading due to Manure Application to Crop Lands =

(162 to 538 x 10^3 lbs/yr) x (0.05) = 8,100 to 26,900 lbs/year

EGG FARMS

1. [Maximum Nitrogen Loading] =

   [Nitrogen Generated per Hen per Year] x [Number of Hens] x [1 - Nitrogen Loss Fraction]

   [Nitrogen Generated per Hen per Year] = 307 kg N/1000 kg live wt (typical live wt = 1.8 kg)
   [Nitrogen Loss Fraction] = 40 - 60% for Open Lot Storage
   [Number of Hens] = 230,000

   [Maximum Nitrogen Loading] = (307 kg N/1,000 kg live wt) x (1.8 kg live wt) x (230,000 hens) x (0.4 to 0.6) x (2.2046 lb/1 kg)

   = 112,080 to 168,120 lbs/year

2. Potential Nitrogen Loading =

   [Maximum Nitrogen Loading] x [1 - Nitrogen Loss Fraction]

   [Nitrogen Loss Fraction] = 10 to 20 % due to denitrification

   [Potential Nitrogen Loading] = (112,080 to 168,120) x (0.8 to 0.9)

   90 to 151 x 10^3 lbs/year

FOOD PROCESSOR A

[Potential Nitrogen Loading] =

[Concentration of Total Nitrogen] x [Daily Flow Rate] x [Leaching Fraction]

[Concentration of Total Nitrogen] = 8 mg/l
[Daily Flow Rate] = 320,000 gallons/day
[Leaching Fraction] = 20 - 30%

[Potential Nitrogen Loading] = (8 mg/l) x (320,000 gallons/day) x (0.20 to 0.30) x (365 days/yr) x (3.7854 L/gal) x (1 g/1,000 mg) x (0.0022 lb/g)

= 1,556 to 2,334 lbs/yr

COGENERATION FACILITIES

[Potential Nitrogen Loading] =

[Concentration of Total Nitrogen] x [Daily Flow Rate] x [Leaching Fraction]

[Concentration of Total Nitrogen] = 36.4 mg/l
[Daily Flow Rate] = 100,000 gallons/day
[Leaching Fraction] = 20 - 30%

[Potential Nitrogen Loading] = (36.4 mg/l) x (100,000 gal/day) x (0.20 to 0.30) x (365 days/yr) x (3.7854 L/gal) x (1 g/1,000 mg) x (0.0022 lb/g)

= 2,213 to 3,319 lbs/year

SEWAGE TREATMENT FACILITIES

[Potential Nitrogen Loading] =

[Concentration of Total Nitrogen] x [Daily Flow Rate] x [Leaching Fraction]

[Concentration of Total Nitrogen] = 0.67 mg/l
[Daily Flow Rate] = 5.0 x 10^6 gal/day
[Leaching Fraction] = 20 - 30%

[Potential Nitrogen Loading] = (0.67 mg/l) x (5.10 x 10^6 gal/yr) x (0.20 to 0.30) x (365 days/yr) x (3.7854 L/gal) x (1 g/1,000 mg) x (0.0022 lb/g)

= 2,077 to 3,116 lbs/year

SEWAGE DISPOSAL PITS

[Potential Nitrogen Loading] =

[Number of Residents] x [Concentration of Total Nitrogen] x [Flow Rate] x [Leaching Fraction]

[Number of Residents] = 275
[Concentration of Total Nitrogen] = 40 mg/l
[Flow Rate] = 70 gpd
[Leaching Fraction] = 20 - 30%

[Potential Nitrogen Loading] = (275) x (40 mg/l) x (70 gal/day/capita) x (0.20 to 0.30) x (365 days/yr) x (3.7854 L/gal) x (1 g/1,000 mg) x (0.0022 lb/g)

= 468 to 702 lbs/year

MUSHROOM FARMS/COMPOSTING OPERATIONS

[Potential Nitrogen Loading] =

[Concentration of Total Nitrogen Loading] x [Daily Flow Rate] x [Leaching Fraction]

[Concentration of Total Nitrogen] = 85 mg/l
[Daily Flow Rate] = 3,000 gal/day
[Leaching Fraction] = 20 - 30%

[Potential Nitrogen Loading]= (85 mg/l) x (3,000 gal/day) x (0.20 to 0.30) x (365 days/yr) x (3.7854 L/gal) x (1 g/1,000 mg) x (0.0022 lb/g)

= 155 to 233 lbs/year

GREENHOUSE OPERATIONS

[Potential Nitrogen Loading] =

[Nitrogen Application Rate] x [Total Fertilized Acreages] x [Leaching Factor]

[N-Fertilizer Application Rate] = 200 to 1,000 lbs/acre/yr
[Nitrogen Application Rate] = (200 to 1,000 lbs/acre/yr) x (0.3) = 60 to 300 lbs/acre/yr
[Total Fertilized Acreages] = 602 acres
[Leaching Fraction] = 30%

[Potential Nitrogen Loading] = (60 to 300 lbs/acre/yr) x (602 acres) x (0.30)

= 10,800 to 54,000 lbs/yr

January 30, 1996

IDENTICAL LETTER SENT TO ATTACHED LIST OF ADDRESSES

Ladies and Gentlemen:

Subject: Llagas Basin Nitrate Study—Response to Comments on Public Draft Final Report

This letter transmits our response to comments on the "Public Draft Final Report" as raised by the Technical Advisory Committee, representatives of state and local agencies, Santa Clara Valley Water District Board members, and the public during the Focus Meeting on September 28, 1995, and/or the Public Workshop on December 12, 1995.

If you have any questions, please contact me at the Camden Office, (408) 927-0710, extension 2743.

Sincerely,

ORIGINAL SIGNED BY

Michael J. Duffy, R. G.
Senior Water Quality Specialist
Water Resource Management

Enclosure: Responsiveness Summary

cc/enc: K. Whitman, B. Allen, M. Carbon (2 for off-site storage), L. Ferrari (for library), J. Townsend (for Library), M. Duffy (2), M. Silva, K. Parton

KP:lcg:CT0129e

SANTA CLARA VALLEY WATER DISTRICT'S LLAGAS GROUNDWATER BASIN NITRATE STUDY

Transmittal of Responsiveness Survey

January 30, 1996

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LLAGAS GROUNDWATER BASIN NITRATE STUDY
RESPONSIVENESS SUMMARY

During the Focus Meeting on September 28, 1995, and the Public Workshop on December 12, 1995, the Santa Clara Valley Water District (District) solicited input from the Technical Advisory Committee, representatives of state and local agencies, District Board members, and the public. These answers are in response to specific questions and comments raised concerning the Draft Final Report, dated August 1995. Most of the questions were incorporated into the report itself and/or will be addressed in the implementation phase. Duplicate questions were consolidated, and questions serving only to provide clarification to the discussion were eliminated.

GENERAL

1. How many wells have been sampled?

The District reviewed historical data for 837 wells and sampled and analyzed 28 wells (pages 8-23,27) for this study.

2. How many cases of methemoglobinemia have been reported in Llagas Basin?

The number of cases of methemoglobinemia in Llagas Basin is unknown due to the lack of requirements for the reporting of cases. It is likely that some individuals have suffered early stages or symptoms of methemoglobinemia without report (Nitrate and Nitrite in Drinking Water, National Academy Press 1995) and were not aware of the link to nitrate exposure.

3. Where is the water blended?

Water blending, or mixing water with high nitrate concentrations with water with low nitrate concentrations, can help produce a drinking water supply with nitrate concentrations less than the Maximum Contaminant Level (MCL). Municipal water suppliers have testing requirements that are not imposed on private well owners. These testing requirements are designed to ensure a supply of safe drinking water for municipal water customers.

The cities of Morgan Hill and Gilroy are responsible for the quality of water delivered to their customers and currently administer water blending operations as needed. "During implementation of the (District's) recommendations, the cities would be responsible for continuing or modifying their water blending programs" (page 70). The District also recommends that "large commercial and industrial sites consider (water blending)" and plans to educate owners of domestic water supply wells about this approach as part of the public education program (page 64).

4. Is the imported water used for District recharge operations currently tested?

Water imported for use in groundwater recharge operations is tested before it is used.

5. **Is there a way to chemically alter nitrate (i.e., put additives in septic tanks)?**

   The District is aware of the current use of bacteriological remediation of effluent at some sewage treatment facilities and new septic tank systems are being developed that will reduce nitrate discharges.

6. **Maybe members of the Nitrate Study should coordinate efforts with Mr. Scott Akin (of the District's Water Conservation Group.)**

   Discussions have already taken place concerning the coordination of efforts between groups. Members of the Nitrate Study Team are currently exploring ways to best combine efforts.

7. **A correction should be made on page 69 to read, "and human health" as opposed to "not human health."**

   Changes have been made to read, "County Environmental Health is responsible for environmental and human health" (page 69).

8. **Correction: "California Administration Code" should be changed to the "California Code of Regulations."**

   Corrections have been made to the report.

9. **Change the wording on page 63 from "point of use" to "point of potable water use" to ensure consistent definition of terms amongst agencies.**

   Changes have been made to the report.

10. **On page 48 of the report, the wording should be changed to clarify the intent of the Basin Plan. The Basin Plan requires a groundwater quality standard of 5 milligrams per liter (mg/L) nitrate nitrogen, not a 5 mg/L standard for the discharger.**

    The wording has been changed to more accurately reflect the intent of the Basin Plan.

11. **Beginning on page 45 with the discussion of "Point Source Institutional Mechanisms," please clarify that not all agriculturally-related dischargers are regulated. The Central Coast Regional Water Quality Control Board (CCRWQCB) determines whether or not to regulate a facility based on the potential for the operations associated with that facility to degrade water quality. In other words, if it appears that potential problems may exist, the CCRWQCB would most likely regulate that facility. However, if the facility is properly managing wastes, etc., and appears to not pose a threat to groundwater quality, then the CCRWQCB will most likely not regulate the facility.**

    A statement has been added to the opening paragraph of that section to clarify how point sources are regulated by the CCRWQCB. Wording in each of the subsections (e.g., dairies) has been changed accordingly, as well.

12. **Footnotes to Table 7 would help clarify the contents of the table.**

    Footnotes explaining the contents of the table have been added.

DATA REVIEW/DATA ANALYSIS

13. **The report should give the public some information regarding how the city wells are testing, as well as some information on how nitrates impact human health.**

As part of the historical data review, the District reviewed approximately 837 wells (page 8). This phase of the study is discussed in more detail in the "Nitrate Data Review" report, dated August 1993. The District sampled and analyzed 28 wells for the study, and general concerns about the water quality in the basin should be directed to the water supplier and/or County Environmental Health. Impacts of nitrates to human health are addressed on pages 1 and 8 of the "Draft Final Report."

14. **In the Sample Analysis section of the report, nitrate concentrations are discussed. CCRWQCB recently prepared nitrate isocontours for Llagas groundwater basin. The District may want to take a look at them for comparison purposes.**

The Sample Analysis phase of the study has been completed. However, the District is working to obtain copies of the CCRWQCB's nitrate isocontours. The District will continue to monitor nitrate occurrence as part of the Basinwide Groundwater Quality Monitoring Program, and CCRWQCB's information will supplement information the District plans to gather.

15. **Why does the District think the trend indicates increasing nitrate concentration?**

The District's sampling data supports "the generally increasing trend of nitrates (seen) in the historical data review . . . Graphs depicting (the) trend analysis are shown in Figures 13 through 18" (page 31).

16. **How did the District take into account differences in seasons of sampling?**

The District sampled and analyzed 28 wells in December 1993 (before winter rains) and March 1994 (after winter rains). Nitrate concentrations of December's sampling event varied only slightly as compared to that of March's. Certain wells sampled higher nitrate concentrations in December, while others had higher concentrations in March.

17. **Did the District look at any samples of run off?**

To accurately calculate nitrogen loadings from rainwater as a source, an intensive study should be performed. Such a study is beyond the scope of this project. However, rough estimates of the nitrate loadings were made and calculated in the "Nitrate Source Area Identification" report, dated December 1994 (Appendix B), and samples of rainwater were collected and analyzed as part of the study.

18. **What kinds of well construction data (e.g., depth) was known?**

Complete well construction information was available for 25 of the 28 wells that the District sampled. The District outlined the well construction information in Table 3 (pages 24 to 26), including well depths and screened intervals. Sample results indicated only a loose correlation between well construction and nitrate concentrations; nitrate concentrations were lower in wells deeper screened intervals (see below).

19. **Is there any correlation between concentrations and depth?**

Nitrate is present at all depths sampled. Of the wells sampled by the District, the general trend showed lower, but not insignificant, nitrate concentrations in deeper water-bearing zones. Discussion of the vertical distribution of nitrates is found on page 21 of the "Sample Analysis" report, dated May 1995. Figures 5 through 7 summarize the findings.

20. **The city wells are about 600 feet deep; are they being tested?**

All municipal (city) wells are tested on a regular basis. Any water from these wells with nitrate concentrations above the MCLs is either treated and/or blended. City well data was incorporated into the District's study of historical data; however, no city well data was included in analysis of current trends.

SOURCE AREA IDENTIFICATION

21. **Is the aquifer recharged from outside the basin? If so, the nitrate could be coming from outside the basin.**

No. The groundwater in Llagas Basin originates in the Llagas Basin Drainage. Groundwater north of Cochran Road flows north and ultimately to the San Francisco Bay. Groundwater flows south from Cochran Road and is recharged from waters flowing from the Santa Cruz Mountains and the Diablo Range. Groundwater in the basin continues to flow south until it reaches the Pajaro River. Nitrates found within Llagas Basin originate within the confines of the Llagas Basin Drainage.

22. **There is a concern for contamination of downgradient wells from upgradient sources.**

This is a valid concern, but it is difficult to determine up and downgradient relationships and if the nitrate found in a specific well originated from a known upgradient source. "Preferential migratory pathways and irregularities in local groundwater flow may exist and can cause a distant nitrate source to actually become a significant source" (page 38). Also, "due the nature, extent, and number of potential nitrate source in Llagas Basin, it is difficult to determine the exact amount of nitrogen loading contributed by each particular source. Detectable concentrations of nitrate discovered in a well today may be from a single source, or from a combination of sources. Past nitrate management practices, or lack of them, may still be affecting groundwater quality in the basin, because transport and transformation of nitrogenous compounds from the ground surface to groundwater may take months or years depending on local subsurface conditions" (page 20). The reality that "nitrates in any given well may originate from a mix of two or more sources," (page 38) supports the need to implement the District's recommendations to reduce nitrate loading and monitor nitrate occurrence in Llagas Basin.

23. **The report does not represent the real problem of chemigation—specifically the hazards and seriousness. Chemigation, however, may not necessarily be a problem if addressed correctly. It needs to be addressed in the regulations.**

The existing regulations concerning chemigation (page 45) require backflow prevention devices on all wells using chemigation. The District will begin work with the agricultural community to ensure that backflow prevention devices are installed on all wells utilizing chemigation.

24. **Where are most of the septic tanks? Are they in any particular concentrated location?**

Septic tanks are located throughout the entire basin, though "the areas of San Martin and certain unincorporated areas of Gilroy and Morgan Hill are the most likely areas to have significant nitrate contributions from septic tanks" ("Nitrate Source Area Identification" report, page 17).

25. **Please explain how the sample calculation for nitrogen loading from fertilized agricultural lands was derived. Where did the numbers come from?**

The average nitrate application rate for crops was obtained via interviews with farmers in the area and from the Santa Clara County Farm Bureau. A discussion of how the District performed the actual calculations for loadings by nitrogen-fertilized agricultural lands is found on pages 13 and 16. These calculations are "based on equations from the State Department of Water Resources land use surveys, Agricultural Chemical Usage Reports by United States Department of Agriculture, Survey of Fertilizer Use in California by the Division of Agricultural Sciences at the University of California, and information from experts and technical literature (page 13). In particular, sample calculations and other pertinent data presented in the Guidance Manual at UC Davis are used wherever appropriate and/or applicable" (page 12). The sample calculation is found in Appendix B of the "Nitrate Source Area Identification" report, dated December 1994.

26. **Looking at Table 6 (page 36): What about pre-1990 data for agricultural land fertilized with cattle manure?**

Although the District looked at land use information and relative loadings for the different nitrate sources since 1967, some specific loadings were not available for years prior to 1990. The data available is listed in Table 6 (page 36).

27. **What is the impact of clippings as opposed to commercial fertilizer application?**

Clippings as a potential source of nitrate contamination was not specifically addressed in the District's "Draft Final Report;" however, the University of California at Davis (UCD) discussed the two sources (clippings versus commercial fertilizer) in a report titled, "Identification and Evaluation of Methods for Determining Sources of Nitrate Contamination in Groundwater" (June 1994). In UCD's report, nitrogen isotope ratios of fertilizer sources "could not be distinguished from that of native soil organic matter." In areas where both clippings and commercial fertilizers are applied to the soil, it is nearly impossible to determine the impact of each individual source.

28. **Did the District look at the loadings of horse manure in San Martin?**

The "Nitrate Source Area Identification" report, dated December 1994, discusses the nonpoint source nitrate loadings from horse manure in the section entitled, "Domestic Livestock" (pages 19-20). Loadings are calculated basinwide, not just in San Martin, and other domestic livestock such as sheep and lambs were included in the report.

29. **It seems that the sewage facility probably contributes more nitrates than all septic tanks combined.**

On page 36, Table 6 summarizes the relative contributions of all point and nonpoint sources in Llagas Basin. Based on the District's calculations, the potential contribution from all septic tanks in the basin totals 53,000 to 151,000 pounds of nitrogen per year. Because of treatment to reduce nitrate, sewage treatment facilities in Llagas Basin potentially contribute approximately 2,100 to 3,100 pounds of nitrogen per year.

30. What do earlier reports say about the area around the sewage farm?

Sewage disposal pits were historically used but are no longer in use today. Calculations for the potential nitrogen loading were included in the study and reflect a relatively small contribution as compared with septic tanks and fertilized agricultural lands ("Nitrate Source Area Identification" report, page 34). Greater discussion of sewage disposal pits and their contribution of nitrates in Llagas Basin is found in the "Nitrate Source Area Identification" report, dated December 1994.

31. The sewage plant mentioned in the study is now testing at approximately 5 mg/L, which is below the MCL (10 mg/L).

The District used 1993 sewage plant discharge data to calculate potential nitrogen loadings from the sewage plant. The District will edit the report to inform readers of the new discharge level.

32. Are landfills currently monitored for nitrates?

Yes, landfills are already monitoring many analytes including nitrate.

IMPLEMENTATION

33. How will the report/study impact the North County?

Although the study addresses sources and loading potentials characteristic to the entire Santa Clara County, the recommendations are geared to reduce nitrate exposure, to reduce nitrate loading, and to monitor nitrate occurrence in Llagas Basin (not countywide). Specific reliance on groundwater as a drinking water source and the severity of nitrate impact from fertilized agricultural lands, septic tanks, cattle feed lots, and egg farms is unique to the South County. This report's recommendations address the needs and protection of the Llagas Basin based on this unique impact and reliance. Possible future recommendations for the North County may be similar or identical to ones in this report.

34. What are the environmentally-correct alternatives to individuals? These alternatives should be considered in the report.

The District appreciates the concern for environmentally-correct alternatives and plans to encourage the use of the alternatives to individuals through the public education program. At that time, these alternatives will be explained in more detail.

35. Who enforces the regulations and recommendations? Where is the money coming from?

Several entities currently enforce regulations regarding land use, water quality, and nitrate contamination. These entities are described in the "Public Draft Final Report" (pages 68 to 70) as agencies the District recommends for implementing the recommendations. Existing institutional mechanisms and related agencies are described on pages 40 to 49, with the Regional Water Quality

Control Board (RWQCB) as the primary regulatory agency. Funding for implementation will come from various sources. Proposed costs are discussed on page 71 and listed in Table 9 (page 73).

36. **Based on recommendations from the District, how likely will the RWQCB enforce land use regulations that are not currently being enforced?**

The District recommends improving and increasing point source regulation. One way is by expanding the definition of waste dischargers to include those that are currently unregulated, such as greenhouses. Enforcement of existing regulations is ultimately up to the RWQCB. The District will work with the RWQCB to ensure that any nitrate management recommendations that include RWQCB enforcement are implemented.

37. **How can the public obtain point-of-use treatment systems?**

This type of information will be addressed in through public education.

38. **What groups will the District be working with during implementation?**

The District will gather input and coordinate with various agencies and groups, as needed. A collaborative effort between agencies, water purveyors, members of the community, and water consumers is planned. A list of recommended implementing agencies is found in the "Draft Final Report" (pages 68 page 70), including a description of their current and/or anticipated roles and responsibilities. The District is already working closely with the Fertilizer Research and Education Program to develop a comprehensive education outreach to the agricultural community.

39. **If the recommendations are implemented, there are needs to be a funding source for County Environmental Health monitoring. Currently, monitoring is voluntary. Where is the money going to come from to increase monitoring of private wells?**

The District believes that increasing the frequency of private well monitoring is a viable way to monitor nitrates in the basin, thereby protecting human health. Private monitoring is relatively inexpensive; well owners would pay for monitoring.

40. **Backflow prevention will have difficult implementation, no matter what.**

The District recognizes the problems associated with backflow prevention implementation. Through public education, the District plans to inform well owners of the problem and provide possible solutions. The District will work with the agricultural community to ensure that backflow prevention devices are present on all wells utilizing chemigation.

41. **How will the recommendations for alternatives to septic tanks affect property owners?**

The District plans to outreach to property owners concerning septic tanks as part of the public outreach program. Alternatives to septic tanks will be considered for implementation 5 to 10 years from now (page 64).

42. **On page 51 of the report, an on-site sewage disposal system is suggested as an alternative to septic tanks. The CCRWQCB doesn't feel comfortable with this alternative system as a solution. Santa Cruz Environmental Health Department has more information regarding these systems.**

The information in Table 6 (page 51) is the result of brainstorming sessions held at the first few Technical Advisory Committee meetings. This option is not an option the District recommends at this time. However, as seen on page 64, this option may be considered 5 to 10 years from now as an alternative to septic systems. The District appreciates your input and will contact Santa Cruz and other entities about their experiences with septic tank alternatives.

43. **The report should list another option to the recommendations: wastewater reclamation. Wastewater reclamation is a way to improve effluent quality as well as help solve our water supply needs. More research is needed.**

The District has mentioned this option under Future Considerations. In other words, this is an option to be considered 5 to 10 years from now, when additional information is gathered about nitrate occurrence in the basin and about the benefits of wastewater reclamation.

44. **There are concerns to people in the study area regarding property value. Also, there is an expected increased market of water treatment systems after implementation.**

The District hopes to educate both realtors and the public on this issue.

45. **The CCRWQCB agrees that point source regulations should be increased; however, staffing and funding limitations currently exist.**

The District appreciates CCRWQCB's support of the recommendation and agree that some limitations may exist when trying to implement these recommendations. However, the District plans to work with the appropriate agencies to resolve such issues as schedules, budgets, and staffing.

46. **Are there any recommendations concerning leach lines?**

All the recommendations are outlined on pages 63 page 67 and none specifically address leach lines. Future considerations may address this concern 5 to 10 years from now.

47. **What specific public education information approach is planned? Maybe the District could supply brochures or pamphlets to the public with basic information such as: "Things that are in your water."**

The report provides an overview of the public outreach planned (pages 63,65) but the District will take this suggestion into account during implementation and public outreach.

48. **Would it be beneficial to put together a layperson's version, especially concerning public outreach? Also, maybe some of the tables/numbers could be summarized on some type of loose-leaf page in the front of the report.**

This report is actually a summary of the study already. However, the District concurs that a plain-language summary would be beneficial. One is now available from the District. This fact sheet includes a brief explanation of the study and District recommendations.

49. **Part of the public outreach could include information about "Where the water comes from."**

The District will address this concern through public education.

50. **During the implementation of the agricultural portion of the public education program, the District should look at the Coastal Zone Management Act for ideas.**

The District plans to obtain this document and review it during the implementation phase.

March 8, 1996

IDENTICAL LETTER SENT TO ATTACHED LIST OF ADDRESSES

Ladies and Gentlemen:

Subject: Transmittal of Llagas Groundwater Basin Nitrate Study, Final Report

The Santa Clara Valley Water District (District) is pleased to transmit the Llagas Groundwater Basin Nitrate Study, Final Report (Report). The Report summarizes the findings of the Llagas Groundwater Basin Nitrate Study and gives recommendations for nitrate management in the Llagas Basin. The Report was completed as per the requirements of State Water Resources Control Board Contract No. 1-053-250-0.

If you have questions about the Report or about the study, please call me at the Camden Office, (408) 927-0710, extension 2743.

Sincerely,

ORIGINAL SIGNED BY

Michael J. Duffy, R.G.
Senior Water Quality Specialist
Water Resource Management

Enclosure

cc/enc: S. Williams, K. Whitman, B. Allen, M. Carbon (2 for off-site storage), L. Ferrari (for library), J. Townsend (for library), M. Silva, K. Parton, M. Duffy (2)

MD:cdh:CT0228b

SANTA CLARA VALLEY WATER DISTRICT'S
LLAGAS GROUNDWATER BASIN NITRATE STUDY

Transmittal of Llagas Groundwater Basin Nitrate Study—Final Report
February 29, 1996

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